# PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL

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— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

DRAFT FINAL
DETAILED ANALYSIS
OF ALTERNATIVES REPORT
VERSION 2.0
EXECUTIVE SUMMARY
VOLUME I OF VII

JULY 1993
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THE CONDUCT OF THE FEASIBILITY STUDY (FS) UNDER CERCLA IS ACCOMPLISHED IN TWO STEPS. THE FIRST STEP, THE DEVELOPMENT AND SCREENING OF ALTERNATIVES (DSA), INVOLVES IDENTIFYING AND SCREENING A BROAD SELECTION OF ALTERNATIVES THAT ACHIEVE THE REMEDIAL ACTION OBJECTIVES (ROAS). THE SECOND STEP IS THE DAA. THE OBJECTIVES OF THE DAA INCLUDE THE FOLLOWING: (1) PROVIDE A MORE DETAILED DEFINITION OF EACH ALTERNATIVE RETAINED IN THE DSA, AS NECESSARY, WITH RESPECT TO THE VOLUMES OR AREAS OF CONTAMINATED MEDIA TO BE ADDRESSED, THE TECHNOLOGIES TO BE USED, AND ANY PERFORMANCE REQUIREMENTS ASSOCIATED WITH THOSE TECHNOLOGIES. (2) ASSESS EACH ALTERNATIVE AGAINST THE DAA EVALUATION CRITERIA IDENTIFIED IN THE NATIONAL CONTINGENCY PLAN AND DEFINED IN U.S. EPA GUIDANCE (EPA 1988). (3) PERFORM A COMPARATIVE ANALYSIS AMONG THE ALTERNATIVES TO EVALUATE THE RELATIVE PERFORMANCE OF EACH ALTERNATIVE WITH RESPESCT TO EACH EVALUATION CRITERION. (4) SELECT A PREFERRED ALTERNATIVE FOR EACH MEDIUM GROUP BASED ON THE COMPARATIVE ANALYSIS. THE DAA REPORT CONSISTS OF SEVEN VOLUMES. VOLUME I - EXECUTIVE

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ROCKY MOUNTAIN ARSENAL

# DRAFT FINAL
# DETAILED ANALYSIS
# OF ALTERNATIVES REPORT
# VERSION 2.0
# EXECUTIVE SUMMARY
# VOLUME I OF VII

JULY 1993
CONTRACT NO. DAAA 05-92-D-0002

Prepared by:

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Prepared for:

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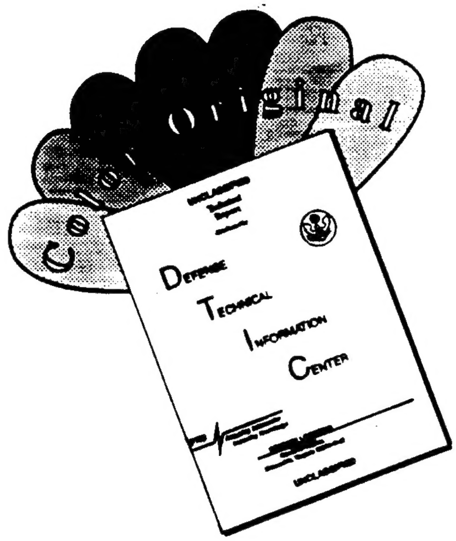


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LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µg/l | micrograms per liter |
| 3-D | three-dimensional |
| ACGIH | American Conference of Governmental Industrial Hygienists |
| ACM | asbestos–containing material |
| AMC | Army Materiel Command |
| AOC | Area of Contamination |
| AOPs | advanced oxidation processes |
| AR | Army Regulations |
| ARARs | applicable or relevant and appropriate requirements |
| Army | U.S. Army |
| atm-$m^3$/mol | atmospheres per cubic meters per mole |
| ATP | Anaerobic Thermal Processor |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BCY | bank cubic yard |
| BDAT | best demonstrated available technology |
| BEST | Basic Extraction Sludge Treatment |
| BFI | Browning Ferris Industries |
| BOD | Biological Oxygen Demand |
| BTEX | benzene, toluene, ethylbenzene, and xylenes |
| BTU | British thermal unit |
| CAMU | Corrective Action Management Unit |
| CAR | Contamination Assessment Report |
| CCA | chromated-copper-arsenate |
| CCR | Code of Colorado Regulations |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| cfm | cubic feet per minute |
| CFR | Code of Federal Regulations |
| CLC2A | Chloroacetic Acid |
| cm/sec | centimeters per second |
| $cm^2$ | centimeters squared |
| COC | contaminant of concern |
| CPE | chlorinated polyethylene |
| CPRP | Chemical Personnel Reliability Program |
| CRL | certified reporting limit |
| CSI | Conservation Services, Inc. |
| CSPE | chlorosulfonated polyethylene |
| CWA | Clean Water Act |
| CY | cubic yards |
| DA | Department of the Army |
| DAA | Detailed Analysis of Alternatives |
| DADS | Denver Arapahoe Disposal Service, Inc. |
| db(A) | decibels |
| DBCP | dibromochloropropane |
| DCPD | dicyclopentadiene |
| DDE | dichlorodiphenylethane |
| DDT | dichlorodiphenyltrichloroethane |
| DHHS | Department of Health and Human Services |
| DIMP | diisopropylmethyl phosphorate |
| DNAPL | dense nonaqueous phase liquid |
| DOD | Department of Defense |

| | |
|---|---|
| DOT | Department of Transportation |
| DRE | destruction removal efficiency |
| DRMO | Defense Reutilization and Marketing Office |
| DSA | Development and Screening of Alternatives |
| EA | Endangerment Assessment |
| Ecology | U.S. Ecology, Inc. |
| EDSVEP | Enhanced Deep Soil Vapor Extraction Process |
| ENSCO | Environmental Systems Company |
| Envirosafe | Envirosafe Services of Idaho, Inc. |
| EOD | Explosive Ordnance Disposal |
| EPA | U.S. Environmental Protection Agency |
| ERC | Ecological Risk Characterization |
| ESSVEP | Enhanced Surface Soil Vapor Extraction Process |
| ETTS | Ecotechniek Thermal Treatment System |
| FC2A | fluoroacetic acid |
| FFA | Federal Facility Agreement |
| FML | flexible membrane liner |
| fpm | feet per minute |
| FRP | fiber - reinforced plastic |
| FS | feasibility study |
| ft/day | feet per day |
| ft | feet or foot |
| $ft^3$ | cubic feet |
| GAA | granulated activated alumina |
| GAC | granular activated carbon |
| GB | isopropylmethylphosphonosfluoridate (nerve agent-sarin) |
| gpm | gallons per minute |
| H:V | horizontal to vertical |
| $H_2O_2$ | hydrogen peroxide |
| HBr | hydrogen bromide |
| HCCPD | hexachlorocyclopentadiene |
| HCL | hydrochloric acid |
| HCPD | Hexachloro pentadiene |
| HDPE | high-density polyethylene |
| HE | high explosive |
| HEP | habitat evaluation protocol |
| HEPA | high efficiency particulate |
| HF | hydrofluoric acid |
| Hg | mercury |
| HHEA | Human Health Exposure Assessment |
| HHRC | Human Health Risk Characterization |
| HI | hazard index |
| ICP | inductively coupled plasma |
| ICS | Irondale Containment System |
| IDLH | Immediately Dangerous to Life and Health |
| IEA | Integrated Endangerment Assessment |
| IITRI | IIT Research Institute |
| IRA | interim response action |
| IT | International Technology |
| IWT | International Waste Technologies |
| $K_{oc}$ | partition coefficient |
| kw | Kilowatt |
| kWh | Kilowatt hour |

| | |
|---|---|
| L | Lewisite |
| lbs | pounds |
| lbs/acre | pounds per acre |
| LCY | loose cubic yards |
| LCY/hr | loose cubic yards per hour |
| LDR | land disposal restriction |
| LF | Linear Foot |
| LNAPL | light nonaqueous phase liquid |
| $LT^3$ | Low-Temperature Thermal Treatment |
| LTTA | Low-Temperature Thermal Aeration |
| mg/l | micrograms per liter |
| $mg/cm^3$ | milligrams per cubic centimeter |
| $mg/m^3$ | milligram per cubic meter |
| mg/kg | milligrams per kilogram |
| mg/l | microgram per liter |
| MKE | Morrison–Knudsen Engineering |
| ml/g | milliliters per gram |
| mm | millimeters |
| MMBTU | million British thermal units |
| mph | miles per hour |
| MTR | minimum technology requirement |
| NaOH | sodium hydroxide |
| NBCS | North Boundary Containment System |
| NCP | National Contingency Plan |
| NEPA | National Environmental Policy Act |
| NWBCS | Northwest Boundary Containment System |
| O&M | operations and maintenance |
| OAS | Organizations and State |
| °C | degrees Centigrade |
| OCP | organochlorine pesticides |
| OCPD | dicyclopentadiene |
| °F | degrees Fahrenheit |
| OPHGB | organophosphorus compounds, GB-agent related |
| OPHP | organophosphorus Compounds; pesticide related |
| OSCH | organosulfur compounds; herbicide related |
| OSCM | organosulfur Compounds; mustard agent related |
| OSHA | Occupational Health and Safety Administration |
| PAHs | polynuclear aromatic hydrocarbons |
| PBC | probabalistic biota criteria |
| PCB | polychlorinated biphenyls |
| pcf | pounds per cubic foot |
| PCP | pentachlorophenol |
| PEC | plume evaluation criteria |
| PKPP | potassium pyrophosphate |
| ppb | parts per billion |
| PPE | personal protective equipment |
| PPLV | preliminary pollutant limit value |
| ppm | parts per million |
| PRG | preliminary remediation goal |
| psi | pounds per square inch |
| PVC | polyvinyl chloride |
| QA/QC | quality assurance/quality control |
| RAO | remedial action objectives |

| | |
|---|---|
| RCRA | Resource Conservation and Recovery Act |
| RF | radio frequency |
| RI | Remedial Investigation |
| RISR | Remedial Investigation Summary Report |
| RMA | Rocky Mountain Arsenal |
| ROD | Record of Decision |
| RPO | representative process option |
| SACWSA | South Adams County Water and Sanitation District |
| SAR | Study Area Report |
| SARA | Superfund Amendments and Reauthorization Act |
| SCC | Secondary Combustion Chamber |
| SEC | Site evaluation criteria |
| SF | square feet |
| Shell | Shell Oil Company |
| SHO | Semivolatile halogenated organics |
| SITE | Superfund Innovative Technology Evaluation |
| STC | Silicate Technology Corporation |
| SVE | soil vapor extraction |
| SVOCs | semivolatile organic compounds |
| SY | square yards |
| T.DI. | Services HT-5 |
| TBC | to be considered |
| TCE | trichloroethylene |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TEA | triethylamine |
| TEC | Target Effluent Concentrations |
| TIS | transportable incineration system |
| TMV | toxicity, mobility, and volume |
| TOC | total organic carbon |
| tpd | tons per day |
| TSCA | Toxic Substances Control Act |
| TSD | Treatment Storage and Disposal |
| TSMG | two-step geometric mean |
| USCS | Unified Soil Classification System |
| USDA | U.S. Department of Agriculture |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| USPCI | U.S. Pollution Control, Inc. |
| UV | ultraviolet |
| UXO | unexploded ordnance |
| VAO | volatile aromatic organic compounds |
| VHC | volatile hydrocarbon compounds |
| VHO | volatile halogenated organics |
| VOC | volatile organic compound |
| VX | ethyl s-dimethyl aminoethyl methyl phosphonothiolate (nerve agent) |
| WES | Waterways Experimental Station |

## 1.0 PURPOSE

The conduct of a feasibility study (FS) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) is accomplished in two steps. The first step, the Development and Screening of Alternatives (DSA), involves identifying and screening a broad selection of alternatives that achieve the Remedial Action Objectives (RAOs). These RAOs are listed in Table ES1.0-1. The range of more promising alternatives retained following screening in the DSA then undergoes an in-depth evaluation during the second step of the FS, the Detailed Analysis of Alternatives (DAA). The objectives of the DAA include the following:

- Provide a more detailed definition of each alternative retained in the DSA, as necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies

- Assess each alternative against the DAA evaluation criteria identified in the National Contingency Plan (NCP) and defined in U.S. Environmental Protection Agency (EPA) guidance (EPA 1988)

- Perform a comparative analysis among the alternatives to evaluate the relative performance of each alternative with respect to each evaluation criterion

- Select a preferred alternative for each medium group based on the comparative analysis

The Rocky Mountain Arsenal (RMA) DAA accomplishes these objectives by following a prescribed sequence of steps, which are described in more detail in the following volumes of this report. Due to the complexity of RMA sites and the unique combinations of contaminants, the standard EPA guidance steps are adapted to site-specific conditions. For example, the number of soil sites, groundwater plumes, and structures being evaluated in the DAA requires the development and use of "medium groups" to identify and evaluate remedial alternatives for groups of sites, plumes, or structures with similar historical usage and that contain similar contaminants and contaminant distributions, that may be remediated using similar technologies. Additional RMA-specific modifications to the DAA process are necessary to integrate the three contaminated media: soils, water, and structures. The proposed remedial alternative for one medium may have a profound impact on proposed alternatives for the other two media. DAA

methodology, as it applies to RMA, is presented in Section 3.0 of the Executive Summary and in each of the volumes related to soils, water, and structures. It should be noted that the cost estimates used in the preparation of the DAA are for comparative purposes only. These estimates are not government cost estimates and should not be used for budgetary purposes.

## SOILS

Human Health

- Prevent ingestion of, inhalation of, or dermal contact with soils or sediments containing contaminants of concern (COCs[1]) in excess of on-post remediation goals.[2]
- Prevent inhalation of COC vapors emanating from soils or sediments in excess of on-post remediation goals for the vapor pathway, as established in the on-post endangerment assessment.
- Prevent migration of COCs from soils or sediments that may result in off-post groundwater, surface water, or windblown particulate contamination in excess of off-post remediation goals.
- Prevent contact with physical hazards such as unexploded ordnance.
- Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards.

Environmental Impacts

- Ensure that biota are not exposed to COCs in surface water, due to migration from soils or sediment, in concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.
- Ensure that biota are not exposed to COCs in soils and sediments in concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.

## WATER

Human Health

- Ensure that groundwater reaching the RMA boundary will be of a quality that is protective[3] of human health as established by preliminary remediation goals at the boundary.

Environmental Impacts

- Ensure that biota are not exposed to biota COCs in surface water in concentrations capable of causing acute or chronic toxicity.

**STRUCTURES**

Human Health

- Prevent contact with the physical hazards associated with structures.
- Limit inhalation of asbestos fibers in structures retained for future use to applicable regulatory standards.
- Limit releases or migration of COCs from structures with manufacturing use-history to soil or water in excess of remediation goals for those media, or to air in excess of risk-based criteria for inhalation as developed in the On-post Endangerment Assessment.

Environmental Impacts

- Prevent contact with the physical hazards associated with structures.
- Prevent biota from entering structures classified as having had manufacturing use history.

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[1] Contaminants of concern are defined as those contaminants specifically identified through the on-post human health risk characterization, the ecological risk characterization, and the off-post endangerment assessment. Reference to the endangerment assessment process is intended to include the exposure assessment, the risk characterization, and the integrated endangerment assessment.

[2] The development of preliminary and final remediation goals, in accordance with the NCP, is an ongoing process requiring continual evaluation of site-specific conditions and evolving health-based criteria and regulatory standards. The remediation goals may change as the FS progresses. Preliminary remediation goals are currently being established for the on- and off-post operable units through the evaluation of applicable or relevant and appropriate requirements (ARARs), health based criteria, Army regulations, the Federal Facility Agreement, ecological risk-based criteria, ambient concentrations of naturally occurring or anthropogenic chemicals, and detection or remediation technology limits.

[3] Protectiveness is defined in the NCP as achieving an excess carcinogenic risk of $10^{-4}$ to $10^{-6}$ or lower and a noncarcinogenic hazard index of less than 1.

## 2.0 INTRODUCTION

The DAA is organized into five major sections: Executive Summary, Soils DAA, Water DAA, Structures DAA, and Technology Descriptions. The Executive Summary outlines the purpose, background, methodology and conclusions found in the remaining volumes. Each medium-specific report (soils, water, and structures) includes introductory, methodological, and analytical sections. The Technology Description Volume describes the technologies and process options used in all alternatives in greater detail than was given in the DSA, and contains the corresponding action-specific applicable or relevant and appropriate requirements (ARARs) for each technology. Chemical- and location-specific ARARs were developed in the DSA (EBASCO 1992 RIC 92363R01) and are not repeated in the DAA. All ARARs will be finalized in the Record of Decision.

## 2.1 BACKGROUND

RMA was established in 1942 by the U.S. Army and was used as a manufacturing facility for the production and dismantling of chemical and incendiary munitions. Industrial and agricultural chemicals, primarily pesticides and herbicides, also were manufactured at RMA by several lessees, most notably Shell Oil Company. Wastes from the manufacturing facilities were initially discharged into Basin A, an unlined basin in Section 36. Subsequently, liquid wastes were discharged into other unlined basins and, after 1956, into Basin F, which was asphalt-lined to minimize leakage. Solid wastes were disposed primarily in Section 36, although other on-post disposal sites also were used. Some of the basins, pits, burn sites, sewers, and structures (buildings, pipes, and tanks) became sources of soil and groundwater contamination as a result of spills, leaks or other releases.

## 2.2 PREVIOUS RESPONSE ACTIONS

In the half century since the Arsenal was built there have been significant advances in our understanding of the effects of industrial and waste disposal practices. As practices once considered appropriate at the Arsenal were found to be unacceptable, they were replaced by better ones, and actions often were taken to remedy adverse effects of the prior practices. For example,

a closed-loop industrial cooling water system replaced the use of South Lakes water, and the South Lakes were extensively dredged to remove contaminated sediments. When unlined evaporation basins were thought to contribute to crop damage miles from the Arsenal, a lined basin, Basin F, was constructed in 1956, which was state-of-art at that time.

Since 1975, the Army and Shell have undertaken numerous efforts to protect on-post and off-post human health and environment through the implementation of source controls and Interim Response Actions (IRAs). These remedial activities were initiated through agreements with both EPA and the State of Colorado for the immediate implementation of treatment or containment actions. Following initial investigations, contamination sources were identified and initial source control actions were developed. These actions included installing three boundary containment systems (the North Boundary, Northwest Boundary, and Irondale Containment Systems), closure of the on-post deep disposal well, applying fugitive dust emission controls for basins, disposing of 76,000 drums of waste salts, removing portions of the chemical sewer system, upgrading the sanitary sewer system, dredging the South Lakes, and enhanced liquid evaporation from Basin F.

In addition to the source control actions, and in accordance with the Federal Facility Agreement (FFA), 13 IRAs were established for implementation prior to the Record of Decision. These 13 IRAs (presented in Table ES2.2-1 and Figure ES2.2-1) were designed to provide immediate containment or treatment of some of the more highly-contaminated areas and thus minimize the potential for exposure to or migration of contamination. These include the closure of many on-post and off-post wells to prevent further contamination of deeper units, application of dust suppressant to bare areas in basins to reduce windblown transport of contamination, improvements to the boundary groundwater systems, construction and operation of several internal groundwater treatment systems, construction of a groundwater treatment system north of RMA, closure and demolition of the hydrazine facility, containment and revegetation of several disposal areas, asbestos removal, and removal of process equipment.

One of the most significant actions taken under the IRA program has been the remediation of Basin F. This IRA included the removal and temporary storage of liquids from the waste pond, the removal and containment of the sludges and underlying soils, and the thermal destruction of 10 million gallons of the temporarily stored liquids. These Basin F actions, initiated in 1988, will continue through the next few years.

These interim response and source control actions, which required significant resources and effort, have resulted in major reductions in the overall environmental impact of the manufacturing/disposal practices of the past. Additional information gathered during the evaluation and implementation of IRAs also has been used by both the Integrated Endangerment Assessment (IEA) and the Feasibility Study. The remaining contamination that poses a threat to human health or the environment is the focus of the current Feasibility Study.

## 2.3 REMEDIAL INVESTIGATION

During the course of the on-post RI, nearly 14,000 samples were collected, including more than 9,600 soil samples from more than 6,000 borings; nearly 300 surface water and 2,000 groundwater samples from 27 surface water sampling locations and 626 groundwater wells; more than 150 samples from 110 on-post structures; 886 air samples from 13 sampling stations; and more than 490 plant and animal samples encompassing approximately 50 species. Samples were analyzed for as many as 60 specific chemical analytes and were screened for hundreds of others. The RI results are presented in more than 230 reports that are summarized in the final Remedial Investigation Summary Report (RISR) (EBASCO 1992). To supplement quantitative information gathered in the RI program, PMRMA established the Comprehensive Monitoring Program, which includes the quarterly and annual sampling of numerous groundwater monitoring wells and weekly air sampling.

In addition to the analytical information collected through the drilling and sampling program, considerable amounts of non-analytical information have been collected from both Army and Shell records, operations logs, and employee interviews. This qualitative information was used

to supplement the quantitative information in the assessment of site risk and site remediation. For example, in the Army Complex Trenches in Section 36, limited physical sampling was done due to the potential presence of unexploded ordnance (UXO) and Army chemical agent (agent). The risks associated with this site and the corresponding remedial alternatives evaluated were based largely on recorded histories of these disposal trenches.

During the course of the Feasibility Study, certain data needs were identified regarding surficial soils contaminant levels, verification of fluoroacetic acid detections during the RI, screening of potential agent sites, and verification of previous sampling data to more thoroughly develop and select the preferred alternatives for on-post soils. Additional pump tests were performed and water quality data were gathered to help validate and calibrate modeling results which were used to develop extraction and treatment alternatives in the Feasibility Study. A pilot demolition program is being conducted to evaluate potential sampling, treatment, and demolition methods for the structures medium.

The RI results are summarized below by media:

- Air - No ambient air problems were detected.

- Biota - Some of the biota contain contaminants above biota "no effects" levels.

- Structures - Approximately one-half of RMA structures were identified as potentially contaminated based on previous use.

- Water - Contaminated groundwater plumes were detected primarily in the vicinity of the basins and North and South Plants. Plumes are primarily moving to the north and northwest. Surface waters did not show repeated detections, but were sporadically impacted by contaminated soils/sediment or by upgradient off-post sources.

- Soils/Sediment - The heaviest contamination was detected in the disposal basins and the South Plants manufacturing area, covering approximately half of the central six section of RMA. Contamination tended to decrease with depth.

The bulk of the contamination is contained in the central sections of RMA in and around the manufacturing complexes, solid waste disposal areas, and liquid waste basins. Data from the RI

regarding the levels and extent of contamination have been used in the IEA to assess risks and develop preliminary health-based cleanup criteria and in the FS to develop and evaluate remedial alternatives for RMA.

## 2.4 INTEGRATED ENDANGERMENT ASSESSMENT/RISK CHARACTERIZATION

The Integrated Endangerment Assessment/Risk Characterization (IEA/RC) was founded on a progressive series of endangerment analyses initiated by the Biota Remedial Investigation (RI; ESE 1989), the Human Health Exposure Assessment (HHEA; EBASCO 1990) and the HHEA Addendum (EBASCO 1992). These initial endangerment evaluations served as screening assessments for human health protection and preliminary estimations of biota criteria, and provided the basic building blocks of the IEA/RC report. The expanded analysis presented in the IEA/RC used updated models and parameters to derive probabilistic risk-based criteria for both human and ecological receptors, presented in the Human Health Risk Characterization and Ecological Risk Characterization sections of the document. The final IEA/RC report is scheduled to be complete in October 1993.

### 2.4.1 Human Health Risk Characterization

The human health risk characterization (HHRC) quantified potential risks for 28 contaminants of concern (COCs) to five potential receptor populations via direct soil exposure pathways (soil ingestion, dermal contact and particulate inhalation) and two indirect exposure pathways (inhalation of soil vapors in open and enclosed areas). Risks were not quantified for groundwater or surface water exposures, or for soil exposures through consumptive pathways (e.g., fruits or vegetables from RMA), due to previously existing restrictions which were continued in the Federal Facility Agreement (FFA).

Human health risks were estimated using probabilistic risk-based criteria referred to in the IEA as preliminary pollutant limit values (PPLVs). For carcinogens, criteria were developed for cumulative excess cancer risks (representing all relevant exposure pathways and COCs) of one-in-a-million ($10^{-6}$ risk) and one-in-ten-thousand ($10^{-4}$ risk). Chronic, subchronic, and acute

risk criteria for noncarcinogens and carcinogens having noncarcinogenic health effects, were estimated as values exceeding a Hazard Index of 1.0, which was considered to be the "benchmark" level. In characterizing potential human health risks at RMA, the following were evaluated in the IEA and are described below:

- site-specific evaluation (for chronic risk, using probabilistic PPLVs)
- boring-by-boring analysis (for chronic risk, using probabilistic PPLVs)
- evaluation of acute/subchronic risks (using deterministic PPLVs developed for the HHEA).

#### 2.4.1.1 Site-Specific Evaluation

For the site-specific analysis, human health risks were estimated using representative contaminant concentrations calculated for each of the 180 sites evaluated in the IEA/RC. In accordance with EPA guidance, the concentration term in the intake equations, termed $C_{rep}$, was calculated as the sample arithmetic mean, and is considered to represent the contaminant concentration that would be contacted at a site over time.

The limitation of this approach, however, is that site boundaries were defined on the basis of historical operations or, in some cases, were defined arbitrarily (e.g., during initial sampling programs). Consequently, these sites may not represent appropriate averaging zones for exposures. For example, based on future land use at RMA, averaging zones would likely differ according to the receptor populations evaluated. Another limitation of the site-specific analysis is that the spatial distribution of contaminants is not apparent in the presentation of results. For many sites, the actual distribution of contaminants is highly skewed. Therefore, to better characterize contaminant variability and facilitate the identification of hot spots, human health risks also were evaluated on a boring-by-boring basis as described below.

#### 2.4.1.2 Boring-by-Boring Analysis

The purpose of the boring-by-boring risk evaluation was to better reflect the spatial distribution of contaminant-specific risks within sites. This analysis has a substantial conservative bias for two reasons: (1) potential risks are calculated using the maximum contaminant concentration at a given boring (for a specified depth interval); and (2) unlike the site-specific analysis, it does not reflect potential average human exposures or risks. However, it allows risk management decisions to focus on the higher risk areas of RMA.

#### 2.4.1.3 Evaluation of Acute/Subchronic Risks

The IEA/RC also summarized the conclusions of the deterministic evaluation of acute and subchronic risks presented in the HHEA Addendum. The risk-based acute and subchronic criteria developed for the HHEA Addendum were computed using a deterministic methodology and were used for screening sites with regard to the potential risks. Although useful in terms of evaluating potential risks due to short-term exposures (of higher magnitude), the results of the acute/subchronic evaluation must be interpreted in light of the fact that a deterministic methodology was used for this evaluation, but a probabilistic methodology was used for PPLV derivation in the IEA/RC.

### 2.4.2 Ecological Risk Characterization Approach

#### 2.4.2.1 Ecological Risk Characterization Approach

In the Ecological Risk Characterization (ERC) the potential risks to biota from exposure to contaminants in soil, sediment, surface water, and other organisms were estimated through a comparison of contaminant concentrations in these media to risk-based criteria developed in the ERC. Ecological target receptors for each trophic box were chosen as those that best exemplified the uptake of contaminants from environmental media and their subsequent transfer through the food chain (bioaccumulation) to top predators. Risk-based criteria for each chemical and each medium were developed for the various feeding levels in a food web model representative of terrestrial and aquatic ecosystems at RMA.

The primary contaminants of concern addressed in the ERC were five organochlorine pesticides and mercury, which are widespread and bioaccumulative. The approach used for each of these contaminants of concern identified the maximum allowable tissue concentrations (MATC) for each target receptor and developed a probabilistic biota criterion (PBC) which represented an acceptable concentration of each contaminant in soil, sediments or water. The lowest 50th percentile PBC for any target receptor within the food web model was selected for each medium to estimate risk. The selection of the lowest PBC (regardless of trophic level) is a conservative approach that results in criteria which are protective of all other trophic levels within the food web.

The dose-based approach was used for eight less widespread and/or nonbioaccumulative chemicals for which risk was also evaluated. This approach incorporates toxicity reference values (TRVs), a similar concept to the reference dose values used in human health risk assessment. The criteria represent concentrations of chemicals in soil, sediment, or surface water that would not be likely to cause adverse effects when an organism is exposed to them on a continuous basis. Selection of the criterion to be used for each feeding level and chemical combination was based on the uncertainty present in each value as discussed below.

#### 2.4.2.2 Limitations of the Ecological Risk Characterization

Similar to the HHRC, the results of the quantitative ecological risk characterization must be interpreted within the context of its inherent limitations and uncertainties. The major sources of uncertainty in the estimated ecological risks include the following:

- selection of target receptors for use in the food webs
- characterization of exposure pathways and trophic relationships within the food webs
- quantification of model input parameters and critical dose values with literature that is incomplete for many species
- procedures used to calibrate and validate the food web model.

The development of risk-based biota criteria involved the use of a complex food web model. Both the structure of the model and the specific input parameters used to define the biomagnification of chemicals by various organisms and the relationships among them contain uncertainties. Professional judgment had to be used in cases where data were lacking. In these cases, decisions were made to incorporate a reasonable degree of conservatism.

Other sources of uncertainty in the ecological risk assessment included the procedures used to define the MATCs and TRVs, and the parameters used to assess the tissue and dose-based toxicological endpoints for the target receptors. Values for these parameters were generally based on minimum adverse effects or no adverse effects levels; however, the data obtained to determine these levels were usually from investigations performed under different study protocols. Both the TRV and MATC protocols, currently under development, will include uncertainty factors to account for some of these sources of uncertainty.

Because of its inherently conservative assumptions, the boring-by-boring approach is not a true representation of average exposure nor a realistic presentation of potential risks. The ERC, like the HHRC, is therefore evaluating the potential risks based on the concept of the home range used by each species, which reflects its actual area of exposure to contaminated environmental media. The home range approach, currently under development, will provide more realistic estimates of site-specific exposure and therefore more realistic PBCs.

Although the uncertainty associated with the ecological risk assessment may result in an under or over estimation of the actual risks, it is highly likely that the overall impact is a conservative or cautious bias resulting in an overestimation of potential risks to biota. These uncertainty considerations will provide a framework within which risk management decisions for protection of the biota can be made.

### 2.4.3 Limitations Common to All Quantitative Risk Evaluations

In addition to the limitations described above, results of the quantitative evaluations must be interpreted within the context of the inherent limitations and uncertainties of the overall endangerment assessment. The factors and assumptions contributing to the uncertainty of estimated risks include:

- limitations of the chemical database
- the methods used to estimate exposure concentrations
- uncertainties in human and biota exposure scenarios used in the risk assessment
- uncertainties in the dose-response models assumed in developing toxicity estimates
- uncertainties in the models and parameters used to characterize risks

Given these uncertainties, parameters were assigned reasonable but conservative values to ensure protectiveness of the exposed populations. With conservative individual parameters, the quantified risk is likely to be highly conservative.

### 2.4.4 Qualitative Assessment

During the RI, sampling locations were generally directed toward known or suspected areas of contamination, not randomly selected. However, some areas at RMA known to be highly contaminated and/or that presented special safety concerns, based on historical information, were not extensively sampled. Consequently, a qualitative assessment was conducted to identify areas of concern which were not addressed in the quantitative assessment. The qualitative assessment focused on the following areas: sites with potential agent or UXO presence; drum disposal sites; underground storage tanks (USTs); burn sites; trenches; sanitary landfills; and spill sites. Additionally, the chemical database was re-evaluated to identify sites where exposure to tentatively identified compounds/unknowns and other chemicals not selected as COCs could pose potential unquantified risks. Results of the qualitative assessment were used to document qualitative risks for sites included in the current FS process to ensure all potential risk areas are considered in the FS, and to evaluate the 64 FS no-action sites to identify any potential qualitative risk not considered in the determination of the no-action designation.

### 2.4.5 Current FS/IEA Coordination

Currently, risk-based criteria are being finalized in the IEA which will be utilized in the Feasibility Study and by risk managers in selecting remedial strategies for areas of significant risk. The scope of this effort entails evaluation of risks posed by on-post soils to human and biotic receptors. This version of the DAA (Draft Final, Version 2.0) uses currently-available criteria, which will change when the IEA is finalized. The finalized IEA criteria must be available for inclusion in the Proposed Final DAA Report in order that risk-based remediation goals may be revised and the evaluation of soil volumes and development of remedial strategies may be updated.

## 2.5 FEASIBILITY STUDY

In 1989, the Army initiated the FS for the on-post operable unit at RMA, developing a methodology that addresses the numerous soils sites, groundwater plumes, and structures using chemical data and historical information provided in the remedial investigation reports combined with human health and biota risk criteria developed in the IEA to identify areas requiring evaluation. Based on this methodology, the FS developed a range of remedial alternatives in accordance with EPA guidance (EPA 1988) and the NCP (EPA 1990a). This range of alternatives, and the results of screening these alternatives based on effectiveness, implementability, and cost, were presented in the DSA report, which was issued in final form on December 21, 1992.

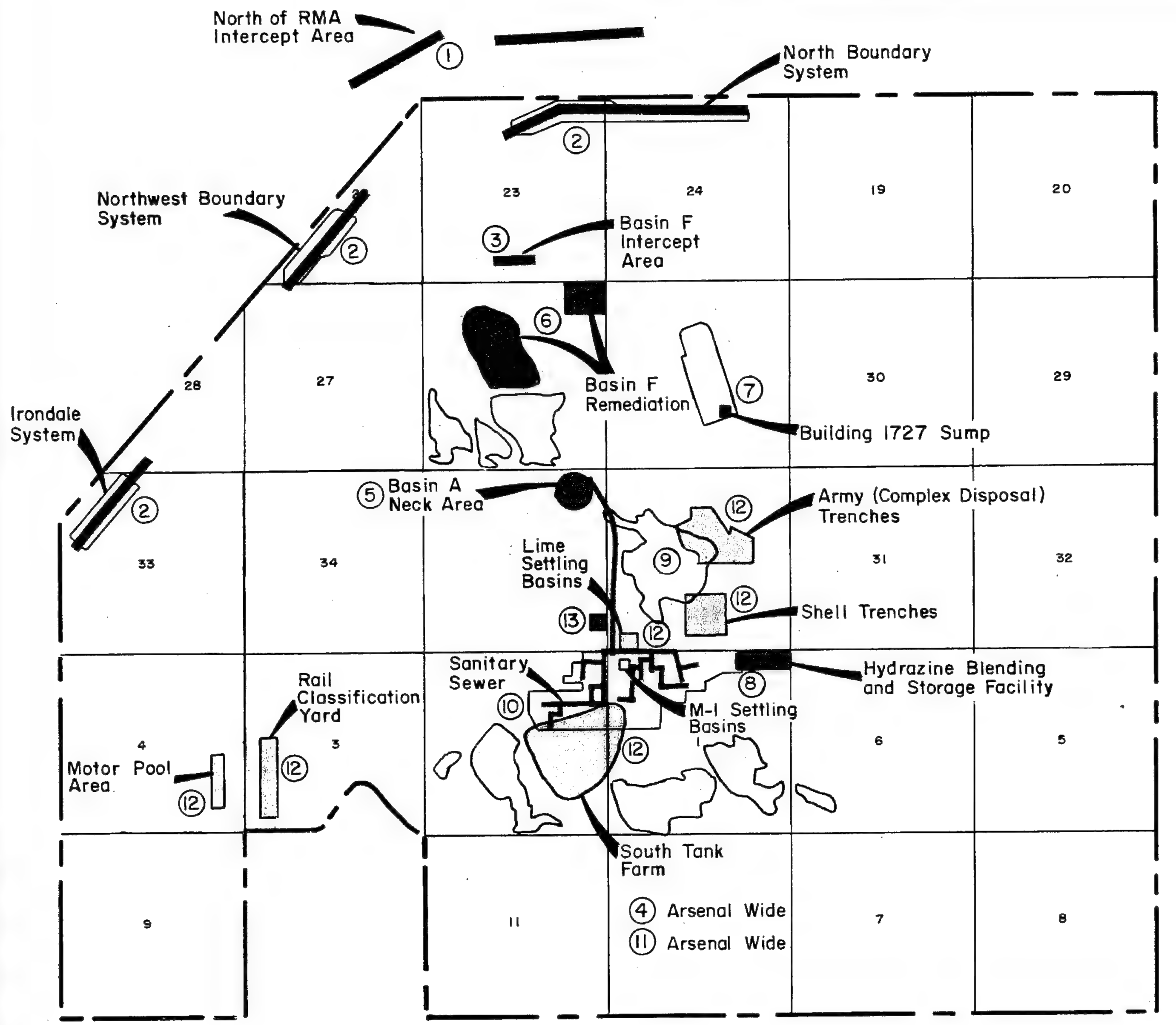
As described in the DSA report, alternatives were developed and screened for each of the sites/medium groups identified as posing an unacceptable risk to human health or biota. Both quantitative and qualitative criteria were used to evaluate risk and identify the appropriate remedial alternatives. During the DAA the alternatives retained in the DSA report were analyzed in additional technical detail and were compared using the EPA criteria outlined in the NCP (EPA 1990a) and CERCLA guidance (EPA 1988 and 1990b), to select a preferred alternative for each site/medium group. This detailed evaluation also took into account the results of treatability studies, additional engineering and cost analyses, operational data from ongoing boundary

systems and IRAs, and field data collected since the DSA was prepared. The methodology for selecting preferred alternatives for soils, water and structures is briefly outlined in Section 3.0, and the results of the evaluations for these media are summarized in Sections 4.0 through 7.0 of the Executive Summary. In general, the strategy for remediation involves more aggressive action for the areas of higher risk with treatment and engineering controls for the balance. This provides for a cost-effective balanced solution involving treatment and containment as outlined in EPA guidance.

Table ES2.2-1 RMA Interim Response Actions



| Interim Response Action | Objective |
|---|---|
| 1. Groundwater Intercept and Treatment System north of the Arsenal | Intercept and treat contaminated groundwater plumes north of RMA to prevent further off-post migration and minimize future exposure. |
| 2. Improvement of the North Boundary Containment and Treatment System and Evaluation of Existing Boundary Systems | Evaluate and improve, as necessary, the North Boundary, and Northwest Boundary and the Irondale Containment and Treatment Systems. |
| 3. Groundwater Intercept and Treatment System North of Basin F | Intercept and treat contaminated alluvial groundwater north of Basin F area, to make the boundary systems more efficient and treat groundwater closer to the source. |
| 4. Vertical Contamination Control | Identify, locate, examine and properly close old or unused wells on RMA to prevent vertical migration of contamination between aquifers. |
| 5. Groundwater Intercept and Treatment System in the Basin A Neck Area | Intercept and treat contaminated groundwater in the alluvial aquifer between Basins A and F, to make the boundary systems more efficient and treat groundwater closer to the source. |
| 6. Basin F Liquids, Sludges, and Soil Remediation | Mitigate the potential for infiltration of contaminants to the groundwater, preclude potential for volatile emissions, eliminate the potential impact of Basin F on wildlife, and final remediation of Basin F liquids. |
| 7. Building 1727 Sump Liquid | Remediate contaminated liquid in the sump to mitigate any remaining threat of release of liquids from this sump. |
| 8. Closure of the Hydrazine Facility | Mitigate the threat of release of wastewater stored at this facility and remediate the above-ground structures. |
| 9. Fugitive Dust Control | Mitigate the threat of the release of wind-blown contaminated dust. |
| 10. Sewer Remediation | Eliminate the RMA sanitary sewers as a potential conduit for contaminant flow. |
| 11. Asbestos Removal | Remove and dispose of friable asbestos on RMA where any potential for human exposure exists. |
| 12. Remediation of Other Contaminant Sources | Mitigate the threat of releases from selected contamination sources. |
| 13. Wastewater Treatment Facility | Treatment of Wastewater resulting from assessment and implementation of Response Actions for RMA. |




## Legend

1. Off-Post Groundwater Intercept and Treatment System
2. Improvement of North Boundary System and Evaluation of Existing Boundary Systems
3. Groundwater Intercept and Treatment System North of Basin F
4. Vertical Contamination Control
5. Groundwater Intercept and Treatment System in the Basin A Neck Area
6. Basin F Liquids, Sludges, and Soil Remediation
7. Building 1727 Sump Liquid
8. Closure of the Hydrazine Facility
9. Fugitive Dust Control
10. Sewer Remediation
11. Asbestos Removal
12. Remediation of Other Contaminant Sources
13. Wastewater Treatment Facility

IRA Location

Other Contamination Sources IRA Locations (Seven sites)

N

0 1 Mile

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE ES2.2-1

Interim Response Action Locations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

## 3.0 DETAILED ANALYSIS OF ALTERNATIVES METHODOLOGY

Based on the NCP and EPA guidance, and consistent with the FFA, the DAA evaluated and compared alternatives retained in the DSA and selected preferred alternatives for remediation of contaminated media at RMA. The DAA consists of the following components:

- Further definition of each alternative, if necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies

- An assessment and summary of each alternative with regard to the EPA evaluation criteria, described in Section 3.2

- A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion

- A selection of preferred alternatives for each medium group

### 3.1 APPROACH

During the DSA, each of the three contaminated media (soil, water, and structures) was subdivided into several medium groups of similarly contaminated soil sites, structures, or groundwater plumes to facilitate and focus the efforts of developing and screening remedial alternatives. The DAA retained the medium-group approach but provided some additional subdivision of sites into subgroups, based on site-specific information, which was required to accurately perform the DAA. Within these medium groups and subgroups, alternatives retained in the DSA, as well as several new or revised alternatives that apply to specific subgroups, were detailed, analyzed, and compared. Comparisons and selection of preferred alternatives were based on EPA evaluation criteria and guidance, as developed in the DSA and retained or revised for the DAA. The criteria developed in the DAA include the following: remedial action objectives (RAOs), preliminary remediation goals (PRGs), site evaluation criteria (SEC) for soils, plume evaluation criteria (PEC) for water, and ARARs. In addition, data collected since the DSA were incorporated as appropriate, and treatability studies, which were initiated in the DSA, were incorporated to provide additional technology information.

## 3.2 EVALUATION CRITERIA

In the DAA, the alternatives retained from the DSA screening process (as well as any modified or newly introduced alternatives) were evaluated for each medium group or subgroup in three basic steps: evaluation of each remedial alternative using the criteria defined in the NCP (40 CFR 300), comparative analysis of the alternative's ability to achieve the requirements of the criteria, and selection of the preferred remedial alternatives that provide the best balance among all criteria. This section discusses the process used to evaluate the remedial alternatives for RMA soils, groundwater, and structures. The methodology is drawn from the NCP and EPA guidance (EPA 1988) and meets the statutory requirements for remedy selection required by CERCLA. Statutory requirements and/or EPA guidance for the selection of remedial actions under CERCLA (EPA 1990b) states that a remedial action must:

- Protect human health and the environment
- Comply with applicable or relevant and appropriate requirements (ARARs) unless a waiver is justified
- Be cost effective
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment as a principal element (of the remedy) or provide an explanation in the ROD why the preference was not met

The nine evaluation criteria that are used to compare remedial alternatives in the DAA establish the basis for the remedy selection decision and demonstrate that statutory requirements are satisfied as defined in the NCP (40 CFR 300.430(e)(9)(iii)). These criteria consist of two threshold criteria, five primary balancing criteria, and two modifying criteria as defined below (from EPA 1990b).

<u>Threshold Criteria</u>

- Overall protection of human health and the environment–This criterion addresses whether or not a remedy provides adequate protection and describes how risks posed through each

exposure pathway (assuming reasonable maximum exposure) are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- Compliance with ARARs–This criterion addresses whether a remedy meets all of the applicable or relevant and appropriate requirements of other environmental laws or whether a waiver can be justified.

Primary Balancing Criteria

- Long-term effectiveness and permanence–This criterion refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.

- Reduction of toxicity, mobility, or volume (TMV) through treatment –This criterion evaluates the anticipated performance of the treatment technologies a remedy may employ.

- Short-term effectiveness–This criterion addresses the period of time needed to achieve protection and any adverse impacts on human health or the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

- Implementability–This criterion evaluates the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

- Cost–This criterion includes the estimated capital and operation and maintenance (O&M) cost and net present worth cost of an alternative. The selected alternative is required by law to be cost-effective.

Modifying Criteria

- State acceptance–This criterion addresses the support agency's comments. Where the state or other Federal agency is the lead agency, EPA acceptance of the selected remedy should be addressed under this criterion.

- Community acceptance–This criterion refers to the public's general response to the alternatives described in the Proposed Plan and the RI/FS report.

Although all nine evaluation criteria are discussed in the following paragraphs, the two modifying criteria are not used in the evaluation process at this stage of the FS. These criteria will be addressed as part of the Proposed Plan and the Responsiveness Summary in the ROD.

### 3.2.1 Threshold Criteria

The two most important criteria, the threshold criteria, are statutory requirements that must be satisfied by any alternative in order for it to be eligible for selection.

#### 3.2.1.1 Overall Protection of Human Health and the Environment

This criterion addresses the overall protectiveness of the proposed remedy by describing how human health and environmental risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. This evaluation criterion acts primarily as a final check on the conclusions reached in applying the other primary balancing and threshold criteria. In particular, this overall assessment of protectiveness draws on the analyses conducted under the compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness criteria. The evaluation of overall protectiveness examines whether an alternative results in any unacceptable short-term or cross-media impacts.

#### 3.2.1.2 Compliance with ARARs

This criterion addresses whether a remedy meets all of the Federal and state environmental laws identified as ARARs. Evaluation of ARARs requires a discussion of how each alternative complies with action-specific ARARs (e.g., emission limits specified for a RCRA-regulated incinerator) and location-specific ARARs (e.g., preservation of endangered species habitat). For RMA soils and structures, there are no chemical-specific ARARs. For groundwater, chemical-specific ARARs include boundary criteria and target effluent concentrations (TECs). Located-specific ARARs are presented in the DSA. The compliance assessment may also include other advisories, criteria, or to-be-considered guidance (TBCs) that the lead and support agencies agree must be addressed. When an ARAR cannot be achieved by an alternative, the evaluation discusses the justification for a waiver (as is allowed under CERCLA).

Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs waivers may be appropriate:

- The remedial action selected is only a part of a total remedial action (interim remedy) and the final remedy is to attain the ARAR upon its completion
- Compliance with the ARAR results in a greater risk to human health and the environment than alternative options
- Compliance with the ARAR is technically impractical from an engineering perspective
- An alternative remedial action can attain an equivalent standard of performance through the use of another method or approach
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances
- Compliance with the ARAR does not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities (for Section 104 Superfund-financed remedial actions)

### 3.2.2 Primary Balancing Criteria

The five primary balancing criteria of long-term effectiveness and permanence, reduction in TMV, short-term effectiveness, implementability, and cost are used to evaluate major performance objectives for alternatives. The relative performance of each alternative is evaluated and compared on a medium-group/subgroup basis to identify any alternatives that are clearly superior or inferior to the other alternatives under consideration. In the report, the balancing criteria are discussed in the order given in the guidance.

#### 3.2.2.1 Long-Term Effectiveness and Permanence

In addition to the specific statutory requirements discussed above, Section 121 of CERCLA guidance emphasizes the preference for treatment to achieve long-term protection and permanence for the proposed remedy. Criteria for evaluating long-term effectiveness and permanence include the following:

- The persistence, toxicity, and mobility of hazardous substances and their constituents and their tendency to bioaccumulate

- The long-term uncertainties associated with containment
- The long-term potential for adverse health effects from human exposure
- The long-term cost of monitoring and maintenance
- The ease of undertaking future remedial action should the proposed alternative fail

These considerations are focused on the magnitude of residual risk remaining after the response objectives have been met. The evaluation of the proposed alternative must include an analysis of the continued potential threat to human health and the environment from untreated waste or treatment residuals remaining at the site after corrective action has been taken. This analytical process includes the following elements:

- Volume and concentration of contaminants in untreated media
- Volume and concentration of contaminants in treatment residuals
- Requirements for 5-year site reviews and long-term monitoring
- Difficulties associated with long-term operations and maintenance
- Confidence in the adequacy of controls
- Availability of equipment used in the alternatives
- Habitat value following remedial actions as compared to existing habitat

The evaluation of long-term impacts on habitat following remediation determines whether the habitat is to be restored following remediation or whether the revegetation of the disturbed areas improves habitat value. If the remedial actions do not improve the habitat at the site, the loss of the habitat during remedial actions is not offset by revegetation activities. In this case, habitat mitigation may be required elsewhere on RMA or off post to offset the loss of habitat during remediation.

#### 3.2.2.2 Reduction of Toxicity, Mobility, or Volume (TMV)

This criterion evaluates the ability of a treatment alternative to reduce the risks at a site through the destruction of toxic contaminants, reduction of the total mass of toxic contaminants, reduction in contaminant mobility, or reduction in the total volume of contaminated media. The NCP (40 CFR 300.430) prefers remedial alternatives that include treatment as a principal element of the remedy over those that do not. Specific considerations include the following:

- Adequacy of the treatment process to address preliminary remediation goals (PRGs)
- Specific requirements and limitations of the treatment process
- Volume of the contaminated media that are treated
- Extent of reduction in TMV
- Irreversibility of the treatment
- Quantities and toxic characteristics of the treatment residuals or byproducts

#### 3.2.2.3 Short-Term Effectiveness

This criterion addresses the period of time during the construction and implementation of the remedy. The evaluation covers community protection and site-worker protection during the remediation period as well as any potential adverse environmental impacts that may result from construction and implementation. For example, poor short-term effectiveness related to concerns over adverse health or environmental impact associated with invasive, excavation-based remedies can weigh significantly against a soils alternative if such risks cannot be mitigated: adequate controls must be implemented to mitigate these impacts. The consideration of environmental impacts during the period of remediation also includes an evaluation of the impact of the remedial action on the quality of habitat.

#### 3.2.2.4 Implementability

This criterion addresses the technical and administrative feasibility of implementing a remedy, including the availability of specialist consultants, materials, and services needed during its implementation. Implementability is particularly important for evaluating sites where highly heterogeneous wastes or mixed media make the performance of some technologies highly uncertain (for example, excavation and incineration of heterogeneous, drummed high-

concentration wastes from a disposal trench). It is also significant when evaluating the reliability of technologies that are less proven and when evaluating remedies that are dependent on a limited supply of facilities, equipment, vendors, or specialists. Specific considerations include the following:

- Ability to construct and operate the alternative within a 10- to 30-year time frame
- Availability and reliability of the components of the alternative
- Availability of equipment and specialists
- Ability to monitor the effectiveness of the alternative
- Demonstrated performance level of the treatment components and equipment and the time required to obtain full-scale components
- Difficulty in implementing future remedial actions once the alternative is in place

The evaluation of implementability also explores the requirements for coordination with other offices and agencies in obtaining permits for off-site activities or access and rights-of-way for remedy construction. The administrative feasibility of remedy implementation may be partially judged from the acceptance of an alternative at the community and state level.

#### 3.2.2.5 Cost

This criterion addresses the evaluation of the capital cost for each alternative as well as the long-term O&M expenditures required to sustain it. Present worth cost analysis is used to compare expenditures that occur over different time periods. By discounting all costs to a common base year, the cost of each alterative can be reduced to a single figure for comparative analysis. The DAA uses a discounted interest rate of 5 percent (as specified in EPA guidance) and an implementation period of 30 years (for long-term O&M) or the actual implementation period (if less than 30 years) for present worth cost calculations.

Cost may play a significant role in differentiating options that appear comparable with respect to long-term effectiveness and permanence or when choosing among treatment options that

provide similar performance. Alternatives with costs that are excessive when compared to overall effectiveness (e.g., in situ vitrification) may not be feasible to implement as a final remedy, and alternatives with low initial capital cost (e.g., a clay/soil cap) may be more costly overall than a treatment alternative when the O&M costs are considered. Higher cost may be offset by improved performance or greater long-term risk reduction in the comparative analysis of alternatives. Ultimately, remedial alternatives that satisfy the CERCLA requirements in the most cost-effective manner will be selected as the preferred alternatives.

### 3.2.3 Modifying Criteria

The two modifying criteria evaluate the feasibility of using the preferred alternative in terms of its acceptance by regulatory agencies and the community at large. These criteria are not evaluated until after the formal public comment period on the RI/FS report and Proposed Plan and are addressed in the ROD. However, agency and community acceptance of the alternatives should be considered as part of the implementability criteria if their positions are known at the completion of the DAA.

#### 3.2.3.1 State Acceptance

State acceptance refers to the state or support agency's comments on the appropriateness of the remedy proposed. The state's position and key concerns about the preferred alternative should be assessed as early in the process as practicable.

#### 3.2.3.2 Community Acceptance

Community acceptance evaluates the issues and concerns raised by the general public in their response to the alternatives described in the RI/FS report and Proposed Plan. Interested persons or groups in the community may support, have reservations about, or oppose some components of the preferred remedial alternative, and their concerns may influence the final selection process.

### 3.3 SITE SPECIFIC CONSIDERATIONS

In addition to the criteria outlined in Section 3.2 above, a number of other qualitative factors influence the evaluation and selection of alternatives. These factors are often based on regulations, policies, or guidance other than that developed specifically for the CERCLA process. The following are a few of the site specific considerations that contribute to the selection of the preferred alternative:

Policy and Regulatory Factors

- Army Policy
- Federal Facility Agreement

Future Land Use Factors

- Long-Term Future Land Use
- Wildlife Management
- U.S. Fish and Wildlife Service Policy

Other Factors Affecting Selection of Remedial Alternatives

- Worker Safety and Health
- Status of Technology Development
- Natural Attenuation of Contaminants
- Community Involvement
- Previous and Ongoing Remedial Actions
- Risk Management

Each of these factors affects the application of EPA evaluation criteria such as implementability, compliance with ARARs, or support agency and community acceptance. In some cases, these factors will dictate an action while in other cases the consideration of these factors will weight the selection criteria to favor certain alternatives.

### 3.3.1 Policy and Regulatory Factors

#### 3.3.1.1 Army Policy

Army policy, in the form of Army regulations and Department of Defense or Department of the Army directives, has a significant effect on the development and analysis of remedial alternatives, particularly in the area of Army materiel. Numerous regulations and procedures have been promulgated by the Army for the safe handling and proper decontamination of Army chemical agent munitions and high explosive munitions treatment and containment requirements for sites where Army materiel may be located.

#### 3.3.1.2 Federal Facility Agreement

The Federal Facility Agreement (FFA) was signed by the U.S. Army, Shell Oil Company, the Environmental Protection Agency, the Agency for Toxic Substances and Disease Registry, the U.S. Fish and Wildlife Service, and the U.S. Department of Justice in 1989. The FFA provides the overall framework for RMA activities, defines responsibilities for the remediation effort, and places certain requirements and restrictions on each signatory. Restrictions include the future land use of RMA, long-term ownership of the property, and the continued prohibition of certain activities such as consumption of on-post groundwater, biota, or agricultural products. The FFA also requires that groundwater quality at the RMA boundary must be protective of off-post receptors. These requirements and restrictions must be taken into account in the development and evaluation of alternatives. Alternatives that do not meet the requirements of the FFA will be determined to not be implementable.

### 3.3.2 Future Land Use Factors

#### 3.3.2.1 Long-Term Future Land Use

Based on Section 2.6 of the FFA:

> "It is the goal of the Organizations that, following certification of completion of the Final Response Action for the On-Post Operable Unit, significant portions of the Arsenal will be available for open space for public benefit (including, but not limited to, wildlife habitat(s) and park(s)) consistent with the terms of this Agreement."

In accordance with the open space goal, the IEA and FS have focused on risk scenarios and alternatives that are compatible with open space. The selection of a preferred alternative must take into account this goal of open space use in the long term.

#### 3.3.2.2 Wildlife Management

Since 1989, the U.S. Fish and Wildlife Service (USFWS) has been actively involved in monitoring and managing wildlife and its associated habitat on RMA, including the numerous bald eagles and a wide variety of prairie vegetation and wildlife that provide a food chain for the eagles. In conjunction with the future goal of open space and in recognition of the unique urban wildlife resources provided by RMA, in October 1992, President Bush signed legislation, enacted by Congress, making RMA as a National Wildlife Refuge following cleanup. The IEA and FS are both affected by the needs of endangered species and other sensitive wildlife populations. Biotic risk is being evaluated in the IEA to determine criteria for soils that will be protective of biota. Alternatives must not only evaluate the long-term risk to biota, but also the short-term risk associated with habitat destruction and need for habitat mitigation. As with human health, short-term risk may impact the selection of the preferred alternative.

#### 3.3.2.3 U.S. Fish and Wildlife Service Policy

In accordance with the open space goal and wildlife management goals, USFWS policies and programs must be acknowledged in the development and screening of alternatives. As the post-cleanup managers of the RMA property, USFWS has developed certain requirements that must be met with regards to remaining structures and enhancement of habitat. USFWS is currently conducting a habitat evaluation program which will determine areas that should not be disturbed due to valuable existing habitat. This program will also determine what mitigation efforts must be completed in areas that are disturbed through remediation efforts.

### 3.3.3 <u>Other Factors Affecting Selection of Remedial Alternatives</u>

#### 3.3.3.1 Worker Health and Safety

Although the IEA and CERCLA guidance largely focus on carcinogenic and non-carcinogenic risks due to long-term exposure to contaminants, short-term risk must be assessed in the selection of alternatives in the DAA. Numerous CERCLA feasibility studies and Records of Decision have selected containment or less-intrusive remedial actions for sites involving significant risk to worker safety or the local community as a result of excavation activities.

The preamble to the NCP offers guidance on when the use of treatment technologies would not be appropriate:

> EPAs "expectations envision treatment of the principal threats posed by a site, with priority placed on treating waste that is highly toxic, highly mobile or liquid; and containment of waste contaminated at low levels, waste technically infeasible to treat, and large volumes of waste... Specific situations that may limit the use of treatment could include sites where (1) treatment technologies are not technically feasible or are not available within a reasonable time frame; (2) the extraordinary size or complexity of a site makes implementation of treatment technologies impracticable; (3) implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation" or (4) severe effects across environmental media resulting form implementation would occur (EPA 1990, pp. 8702-8703).

Some of the sites at RMA include the potential for UXO and Army agent. Disturbance of either of these buried materials could cause immediate physical danger to workers on the site. If an unstable chemical agent munition is discovered, Army policy dictates that the munition be destroyed through detonation in place. In addition, other sites may require specialized handling of soils or structural debris which will require increased levels of worker protection and in some cases, operation in a controlled atmosphere environment. Workers under these conditions are more likely to be injured due to decreased visibility and mobility and increased heat stress.

#### 3.3.3.2 Status of Technology Development

Based on EPA guidance, an effort was made to use innovative technologies to the maximum extent possible in the development of alternatives. Many of these innovative technologies have not been demonstrated on a full-scale or pilot-scale basis or have questionable treatability study and pilot-scale testing results. The evaluation of certain technologies is further complicated by the unique types and combinations of contaminants at RMA that are not normally found at most CERCLA sites. Due to the magnitude of the potential costs for cleanup at RMA, technologies that will be selected for implementation must have a high degree of confidence and be available in sufficient scale to be feasible for RMA remediation. However, treatability and pilot studies of promising innovative technologies will continue through design so that the most effective remedies are used.

#### 3.3.3.3 Natural Attenuation of Contaminants

Natural attenuation is the process by which contaminant concentrations decrease with time under natural environmental conditions, as a result of volatilization, photodegradation, biodegradation, irreversible adsorption, dispersion/dilution, leaching/washout, or other processes. Recent sampling efforts for soils and groundwater have indicated that contaminant levels have decreased since the RI program originally collected samples. This decline in contaminant concentrations may be attributed to natural attenuation processes. Without performing an in-depth, multi-year study, this decline cannot be defined or quantified. Regardless, it should be noted that natural attenuation has probably occurred in soils and groundwater since the contaminants were originally introduced, and at all sites including those where containment, institutional controls or no action alternatives are selected, contaminant concentrations will continue to decrease over time.

#### 3.3.3.4 Community Involvement

As was demonstrated with the existing Submerged Quench Incinerator, community involvement in the alternative selection process may present a different perspective compared to that of environmental scientists, engineers, and risk managers. Community involvement in the on-post FS process is planned for the Fall of 1993 and will include community education workshops. Community issues such as long-term employment of workers, commercial concerns surrounding

the wildlife refuge, community safety concerns, and long-term protectiveness may affect the Army's selection of a preferred alternative. Community concerns not known at this point in the FS process will come to light during community involvement sessions and public review of the RI/FS Report and Proposed Plan and will be considered in the selection of the preferred alternative in the ROD.

3.3.3.5 Previous and Ongoing Remedial Actions

As described in Section 2.2, the Army has implemented numerous source control and interim response actions at RMA during the past 18 years to contain, treat, or dispose of some of the more highly-contaminated materials and to minimize the migration of contamination within RMA and off-post. The presence and adequacy of these response actions must be considered during the FS evaluation of remedial alternatives, for in some cases the existing actions may adequately provide for protection of human health and the environment and comply with ARARs, so that additional remedial actions are not appropriate or necessary. For example, on-post groundwater treatment IRAs and boundary containment/treatment systems have been installed to capture and treat contaminated groundwater plumes. These systems are currently operating and achieving ARARs, so the need for additional remedial alternatives to address these plumes must be evaluated in light of the existing systems. Likewise, several contaminated soil sites have been contained with caps (and in one case, with a cap and slurry wall); the adequacy of these remedial actions in meeting the statutory requirements of CERCLA must be evaluated in comparison to other alternatives under consideration.

3.3.3.6 Risk Management

The selection of alternatives is a two-step process. First, the two threshold criteria (overall protection of human health and the environment and compliance with ARARs) must be evaluated, as each alternative must meet these requirements to be eligible for selection. Following that, the primary balancing criteria and modifying criteria (see Section 3.2) are evaluated. In this step, the technical and cost issues, as well as regulatory agency and public concerns, are weighed to identify a preferred alternative that provides the best balance among

these criteria, while attaining the desired reduction of risk to human health and the environment in a cost-effective manner.

The EPA recognizes that a number of approaches can be taken in achieving risk reduction, which will generally include treatment, containment, and institutional control elements. As stated in the NCP (EPA 1990a):

> "The national goal of the remedy selection process is to implement remedies that eliminate, reduce or control risks to human health and the environment, that maintain protection over time, and that minimize untreated waste.... [While] EPA expects to use treatment to address the principal threats posed by a site, wherever practicable...EPA expects to use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable.... [Thus] EPA expects to use a combination of methods, as appropriate, to achieve protection of human health and the environment" [40 CFR 300.430(a).1].

Following this guidance, the risk manager must evaluate the range of alternatives and select remedies that are cost-effective, i.e., those which best balance the proportional benefits of greater long-term risk reduction with short-term effectiveness (risk during implementation) and cost.

## 4.0 SUMMARY OF THE DETAILED ANALYSIS OF ALTERNATIVES FOR SOILS

### 4.1 ORGANIZATION

The Soils DAA Report is organized into three volumes. Sections 1.0 through 4.0 present an introduction to the Soils DAA, a discussion of interactions between the soils, water, and structures media, the methodology used throughout the Soils DAA, and a description of the DAA alternatives. Sections 5.0 through 19.0 present the detailed analysis of alternatives for each soils medium group. Section 20.0 summarizes the results of the Soils DAA and presents the preferred alternatives for each of the medium groups. Appendix A presents the soil volumes and areas used in the DAA and Appendix B provides the detailed cost tables for each alternative.

### 4.2 SOILS DAA APPROACH

In the DSA, alternatives were developed and screened using information available at that time. During the preparation of the DAA additional data collection programs and treatability studies were performed and the results made available for incorporation into the DAA. The level of detail describing the component processes retained in the DSA was increased in the DAA to support the detailed analysis of alternatives in accordance with the NCP. Additional detail was also developed on remediation time frames to allow evaluation of the implementability of alternatives, and additional costing detail was provided to allow a more accurate comparison of costs.

Soils medium groups were established in the DSA to facilitate the development and screening of alternatives for sites that had a similar historical usage, contained similar contaminants, or were physically collocated. The medium group approach was retained in the DAA, but it was determined that some medium groups should be divided into subgroups, and that the alternatives for the medium groups should be selected and modified as appropriate to apply specifically to the subgroups. Eight of the original DSA medium groups did not require additional subdivision, but the other eight medium groups were further divided into a total of 19 subgroups. Altogether, a total of 27 soils groups were evaluated with regard to a range of alternatives including no action, institutional controls, containment, and treatment alternatives.

Additional alternatives were also developed for the DAA based on the concept of treating principal threats. As defined by EPA guidance (EPA 1991), principal threats include those source materials considered to be highly toxic or highly mobile, that generally cannot be reliably contained or would present a significant risk to human health and the environment should exposure occur. The identification of principal threats focuses the most aggressive remedial actions on the areas of highest risk to human health and the environment, where practicable. Alternatives developed in the DSA were modified to include treatment of principal threat volumes with containment of lower risk areas. For example, Alternative 2 in the Soils DSA involves the use of institutional controls, while Alternative 2a in the Soils DAA combines the direct thermal treatment of principal threat volumes with the use of institutional controls to address the remaining human health exceedance area. The alternatives developed to remediate principal threats provide the greatest amount of risk reduction through treatment in the most cost-effective manner.

## 4.3 ANALYSIS OF ALTERNATIVES

After the alternatives were detailed and modified (if necessary), they were evaluated with respect to the seven DAA threshold and primary balancing evaluation criteria. These analyses are summarized in text and presented in more detail in tabular format in the DAA. The text addresses significant strengths or weaknesses of a particular alternative.

## 4.4 SELECTION OF PREFERRED ALTERNATIVES

Following the analysis of each of the alternatives against the DAA criteria, the comparative performance of each alternative was evaluated, and a preferred alternative was selected for each medium group or subgroup. The selection of the preferred alternatives considered the EPA Threshold Criteria:

- The preferred alternative must be protective of human health and the environment
- The preferred alternative must meet ARARs, or a justification for a waiver of the ARAR(s) must be provided.

Alternatives that did not meet the two threshold criteria or that could not reasonably attain waivers for ARARs compliance were not retained for the comparative analysis. Alternatives were compared using the five balancing criteria, with the relative importance of each criterion depending on site-specific factors. The following subsections describe the alternatives selected for each medium group, which are summarized in Table ES4.4-1 and shown in Figures ES4.4-1 through ES4.4-3.

4.4.1 Munitions Testing Medium Group

The preferred alternative for the Munitions Testing Medium Group, which only has the potential for High-Explosive (HE)-Filled UXO (but no human health or biota exceedances or the potential presence of Army agent), is Alternative U4a: Detonation (Off-Post Army Facility). This alternative is protective since the UXO is removed and treated at a lower risk to workers. However, unstable UXO that cannot be safely excavated will be detonated in place. It also costs significantly less than the other treatment alternatives ($9.3 million versus $17 million). The alternative uses existing facilities, may be more acceptable to the community, and complies with Army regulations for UXO demilitarization.

4.4.2 Agent Storage Medium Group

This medium group consists of the North Plants Subgroup and Toxic Storage Yards Subgroup, both of which may have Army agent present. The preferred alternative for these subgroups is Alternative A4: Incineration/Pyrolysis (Rotary Kiln). This alternative is the most protective alternative for each of these subgroups, as agent-contaminated soils are treated while isolated human health and biota exceedances are contained without generating large quantities of residuals. In addition, this alternative complies with Army regulations regarding agent-contaminated materials. The selection of this alternative necessitates the demolition of associated structures and removal of structural debris. There are no soil/water interactions for the North Plants Subgroup or Toxic Storage Yard Subgroup.

### 4.4.3 Lake Sediments Medium Group

The preferred alternative for the Lake Sediments Medium Group, which contains primarily biota exceedances with limited human health exceedance areas, is Alternative B1a: Caps/Covers (Clay/Soil Cap) with Consolidation (for human health exceedances), with No Additional Action (Provisions of FFA) for biota only exceedance areas. Considering the minimal risk to biota from not meeting biota PRGs in the short term and the significant impact to habitat resulting from removal/treatment alternatives, this alternative is selected as the most protective and cost-effective alternative.

### 4.4.4 Surficial Soils Medium Group

The Surficial Soils Medium Group has only biota exceedances. The preferred alternative for this medium group is Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice). Unlike thermal, solvent extraction, and other treatment alternatives, this alternative does not damage the physical state of the soils during remediation, and the soils are readily revegetated. As a result, the negative impact on habitat, which is a significant consideration for the very large area comprising this medium group, is less than for the other alternatives. This alternative is cost effective since the large exceedance area is treated in place and the area can be readily revegetated, at a lower cost than the other alternatives.

### 4.4.5 Ditches/Drainage Areas Medium Group

This medium group has only biota exceedances. The preferred alternative for the Ditches/Drainage Areas Medium Group is Biota Alternative B5a: Caps/Covers (Clay/Soil Cap) with Consolidation. This alterative is consistent with NCP guidance on engineering controls for low levels of contamination, and by consolidating the soils in Basin A for containment rather than capping them in place, the overall monitoring and maintenance costs at RMA are reduced. In addition, the material excavated from the Ditches/Drainage Areas sites can provide part of the soil required to regrade Basin A for proper drainage prior to capping. As a result, this alternative is considered cost effective for the remediation of the 18,000 BCY of low-level contaminated soils in this medium group.

4.4.6 Basin A Medium Group

The preferred alternative for the Basin A Medium Group is Alternative 6f: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Clay/Soil Cap paired with analogous Caps/Covers alternatives for the biota, agent, and UXO exceedance areas). This alternative is protective of human health and biota because the contaminated material in the principal threat areas is treated prior to containment. This alternative is consistent with the NCP preference (EPA 1990) for selecting treatment for higher levels of contamination and initiating engineering controls, such as containment with a low permeability soil cap, for areas with lower levels of contamination. The lower cost of this alternative (compared to complete excavation and treatment alternatives), combined with the reduction in worker exposure, makes this alternative cost-effective for this medium group. Filling and grading of the basin to promote runoff combined with the installation of a low permeability soil cap and treatment of the principal threat volume significantly reduces the infiltration of surface water and the migration of contaminants to groundwater and surface water.

In addition to providing a cost-effective remediation option for the Basin A Medium Group, this alternative contributes to the remediation of other sites at RMA by consolidating material from these other sites containing lower levels of contamination under the Basin A cap as part of the fill needed to regrade Basin A to achieve adequate drainage. Consolidating low-level contaminated material from other sites into Basin A reduces the number of capping/containment locations at RMA, thereby reducing the areas requiring long-term maintenance. Although additional contaminant mass is placed in Basin A as a result of the consolidation of contaminated soils from other sites, the installation of a low permeability soil cap significantly reduces the risks for future groundwater contamination in Basin A. The debris from the demolition of structures will also be consolidated in Basin A. The structural debris provides a stable subgrade layer for the clay/soil cap.

Thermal desorption of the principal threat volume requires dewatering prior to excavation. The water removed during dewatering will be pumped to the CERCLA wastewater plant for

treatment. The short-term groundwater pumping alternative for Basin A to remove contaminant mass from the core of the contaminated pumps in the basin will be started while consolidation of soils into Basin A is taking place and the clay/soil cap is being installed. This will require close coordination during the design and implementation of the Basin A remedy. Any long-term groundwater pump-and-treat systems and long-term groundwater monitoring will be conducted following the installation of the cap.

4.4.7 Basin F Wastepile Medium Group

The preferred alternative for the Basin F Wastepile Medium Group is Alternative 6e: Caps/Covers (Composite Cap) and modification of the existing leachate collection system. This alternative protects human health and the environment by eliminating exposure pathways and preventing groundwater contamination. The installation of a composite cap does not require the extensive vapor controls or specialized excavation procedures required by excavation/treatment alternatives, and this alternative costs more than an order of magnitude less than any treatment alternatives. This alternative also poses potentially serious safety hazards to the site workers and vapor/odor concerns to the community that could result from excavation of the wastepile. Therefore, Alternative 6e: Caps/Covers is considered the most cost-effective alternative for the Basin F Wastepile.

The NCP (EPA 1990) indicates that treatment alternatives should be selected for materials considered principal threats, wherever practicable, and that engineering controls are appropriate for principal threats where treatment is not practical. EPA guidance on principal threats (EPA 1991) indicates that treatment may not be appropriate for cases where the implementation of the treatment-based alternative results in a greater overall risk to human health and the environment due to the risks posed to site workers and the community during the remedial action. The installation of an additional cover on the wastepile does not involve destruction of the existing cover and exposing the waste. Workers will be able to use commonly obtained earthmoving equipment and significantly less PPE. There will be no risk of odor releases, since an enclosure with vapor controls will not be necessary. As indicated in the referenced guidance

and the preamble to the NCP (EPA 1990), the selection of Alternative 6e: Caps/Covers for the Basin F Wastepile Medium Group is an appropriate exception to the guidance regarding the treatment of principal threats.

4.4.8 Secondary Basins Medium Group

The preferred alternative for the Secondary Basins Subgroup is Alternative 6g: Caps/Covers with Consolidation. Although this alternative has a slightly higher cost than Alternative 6/B5: Caps/Covers, it minimizes monitoring and maintenance costs and reduces the number of capping/containment sites at RMA by consolidating contaminated material (containing lower levels of contamination than Basin A) under the Basin A cap. The selection of this alternative is consistent with NCP guidance on containment for lower levels of contamination. The groundwater control system evaluated for the Basins C and F Plume is located north of the former Basin F. As such, the selection of this alternative does not impact the evaluation of groundwater alternatives.

The preferred alternative for the Former Basin F Subgroup is Alternative 6c: Direct Thermal Desorption; Caps/Covers with Modifications to Existing System. This alternative is cost effective as it treats only the principal threat volume and provides long-term containment of untreated residual soils which contain lower levels of contamination. Fewer short-term impacts result from this alternative because only the principal threat volume of soil (rather than the entire volume) is excavated. This alternative is consistent with NCP guidance on treatment for higher levels of contamination, and engineering controls (i.e., containment) for lower levels of contamination. The groundwater control system evaluated for the Basins C and F Plume is located north of the former Basin F; therefore, the selection of this alternative does not impact the evaluation of groundwater alternatives.

The preferred alternative for the Basin F Exterior Subgroup is Alternative 6g: Caps/Covers with Consolidation. This alternative minimizes monitoring and maintenance costs and reduces the number of capping/containment sites by consolidation. This alternative also improves habitat in

the long term over a 2,300,000-SY area, and it is cost-effective because a small volume of soil is excavated and consolidated, thus disturbing a minimal amount of habitat.

### 4.4.9 Sewer Systems Medium Group

The preferred alternative for the Sanitary/Process Water Sewers Subgroup is Alternative 2: Access Restrictions. This alternative is consistent with NCP guidance on the use of controls for lower levels of contamination and it achieves RAOs, based on the depth of contamination (greater than 6 ft) and the low levels of contamination. Selection of Access Restrictions as the preferred alternative does not impact alternatives developed for the structures or water media.

The preferred alternative for the Chemical Sewers Subgroup is Alternative 3a: Direct Thermal Desorption of Principal Threat Volume; Landfill, along with Alternative A4: Incineration/Pyrolysis for agent-contaminated materials. This alternative addresses the principal threat areas and soils identified to contain agent through treatment; the remaining soils, which have lower levels of contamination, are contained with engineering controls. This alternative is cost effective and is consistent with NCP guidance on treatment of higher levels of contamination and the use of engineering controls for lower levels of contamination.

Areas to be excavated down to the water table will require dewatering, and the extracted groundwater will be pumped to the CERCLA wastewater treatment facility. The dewatering for South Plants could be accomplished as part of a groundwater pump-and-treat system. Several structures will be demolished prior to excavation within South Plants and North Plants. The structural debris will be removed from the area to allow access to the sewers, which limits the range of alternatives for structures.

### 4.4.10 Disposal Trenches Medium Group

The preferred alternative for the Complex Trenches Subgroup is Alternative 5b: Caps/Covers; Vertical Barriers with Consolidation. This alternative has lower short-term impact than other alternatives considered because the soils and debris in the disposal trenches are not excavated,

avoiding the risks of potential exposure of site workers to UXO and agent. The NCP (EPA 1990) indicates that principal threat areas can be addressed by engineering controls where treatment may pose a greater risk, and EPA guidance on principal threats (EPA 1991) indicates that treatment alternatives for principal threats may not be appropriate for cases where the implementation of the treatment-based alternative results in a greater overall risk to human health and the environment (due to the risks posed to site workers and the community during the remedial action) compared to an alternative based on engineering controls. The installation of a clay/soil cap and a slurry wall interrupts exposure pathways and reduces groundwater contamination, while the excavation of the disposal trenches for treatment by rotary kiln incineration results in a greater risk to workers and the community. As indicated in the referenced guidance and the preamble to the NCP (EPA 1990), the selection of Alternative 5b: Caps/Covers; Vertical Barriers with Consolidation for the Complex Trenches Subgroup is an appropriate interpretation of the guidance regarding the treatment of principal threats. As part of the containment of the Complex Trenches Subgroup, long-term dewatering is required to ensure that contaminated groundwater does not leak from the trenches. The groundwater removed as part of this system will be treated at the CERCLA wastewater treatment plant.

The preferred alternative for the Shell Trenches Subgroup is Alternative 14: Incineration/Pyrolysis; Landfill. Although this alternative has a higher cost than the containment alternative, the selection of rotary kiln incineration is consistent with the NCP (EPA 1990) regarding the treatment of higher levels of contamination and principal threat areas. EPA guidance on principal threats (EPA 1991) indicates that treatment alternatives for principal threats may not be appropriate for cases where the implementation of the treatment-based alternative would result in a greater overall risk to human health and the environment (due to the risks posed to site workers and the community during the remedial action), as compared to engineering controls. In this light, modification to the clay/soil cap and vertical barrier will result in significantly lower short-term risks to workers and the community compared to excavation and treatment; however, the short-term risks posed by the excavation of the disposal trenches for treatment by rotary kiln incineration can be adequately addressed (although at significant cost)

by worker safety controls and a vapor enclosure. Therefore, the selection of Alternative 14: Incineration/Pyrolysis; Landfill is consistent with the guidance provided in the NCP and the referenced guidance document.

As part of the rotary kiln incineration of exceedance volumes in this subgroup, dewatering is required to allow the excavation of soils and debris from near the water table. The groundwater removed during dewatering will be treated at the CERCLA wastewater treatment plant.

The preferred alternative for the Hex Pit Subgroup is Alternative 14: Incineration/Pyrolysis; Landfill. Although this alternative has a higher cost than the containment alternative, the selection of rotary kiln incineration is consistent with the NCP (EPA 1990) regarding the treatment of higher levels of contamination and principal threat areas. Although the installation of a clay/soil cap and slurry wall would result in lower short-term risks to workers and the community, the short-term risks posed by the excavation of the hex pits for treatment by rotary kiln incineration are adequately addressed by worker safety controls and a vapor enclosure. Therefore, the selection of Alternative 14: Incineration/Pyrolysis; Landfill is consistent with the guidance provided in the NCP and the referenced guidance document.

The selection of Alternative 14: Incineration/Pyrolysis; Landfill necessitates the demolition of Building 571B and associated structures and the removal of the debris. As discussed in the Structures DAA, structural debris will be placed in Basin A or the South Plants Central Processing Area as grading fill prior to containment of these areas.

#### 4.4.11 Sanitary Landfills Medium Group

The preferred alternative for the Sanitary Landfills Medium Group is Alternative 3: Landfill (i.e., excavate the existing landfills and consolidate in a centralized landfill). Long-term management and maintenance requirements for this alternative are less than the comparable containment alternative (Alternative 5: Caps/Covers; Vertical Barriers) since there will only be one landfill to maintain. The landfill alternative applies engineering controls to reduce contaminant mobility

and interrupt exposure pathways, which makes the alternative cost effective compared to the most likely treatment alternative (Alternative 13b: Direct Thermal Desorption; Landfill). The selection of this alternative is consistent with NCP guidance on the use of engineering controls to address low levels of contamination like those found in this medium group.

4.4.12 Lime Basins Medium Group

The preferred alternative for the Section 36 Lime Basins Subgroup is Alternative 6d: Caps/Covers with Modifications to Existing System. Since less material is excavated, there are fewer short-term impacts on the habitat with this alternative. In addition, the long-term performance of the existing cap is improved with the additional clay/soil cap. This alternative is the most cost-effective alternative since only the principal threat volume is treated and the existing containment system is augmented.

The preferred alternative for the Buried M-1 Pits Subgroup is Alternative 10: Direct Solidification/Stabilization. This alternative is consistent with NCP guidance on treatment of higher level concentrations and provides better controls of the high levels of arsenic than the installation of a cap/cover without treatment. The technology is readily available and implementable, and is the most cost-effective alternative for this subgroup.

4.4.13 South Plants Medium Group

The preferred alternative for the South Plants Central Processing Subgroup is Alternative 6a: Direct Thermal Desorption and Direct Solidification/Stabilization of Principal Threat Volume; Caps/Covers. The alternative is consistent with NCP guidance on treatment for higher levels of contamination and the use of engineering controls (capping) for lower levels of contamination. The installation of the clay/soil cap and treatment of the principal threat volume significantly reduces the migration of contaminants to groundwater. This alternative is cost effective since the principal threat volume is treated and the balance of the exceedance areas are contained; it also contributes to the remediation of soils from other portions of South Plants, which will be consolidated in the Central Processing Area as grading fill prior to capping.

Using lower-level contaminated soils from other portions of South Plants reduces the number of capping/containment locations at RMA, thereby reducing the areas requiring long-term maintenance. Although additional contaminant mass is placed in the Central Processing Area as a result of the consolidation of contaminated soils, the levels of contamination in consolidated soil are lower than those already in place in the Central Processing Area. The installation of a clay/soil cap contains this contamination and significantly reduces the risks of future groundwater contamination in the area of the South Plants Central Processing Subgroup.

The demolition and removal of structures within the Central Processing Area is required to allow the excavation of contaminated soils. Abandoned utilities encountered during excavation will be removed and consolidated with the structural debris. The structures alternatives for this area consider the backfill of the foundation excavations with borrow material; however, the timing of backfilling the excavations and the backfill materials used is dependent on the soils alternative selected for the South Plants Central Processing Area Subgroup.

The preferred alternative for the South Plants Ditches Subgroup is Alternative 6b: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Consolidation. This alternative is consistent with NCP guidance on the use of treatment technologies for higher levels of contamination, and engineering controls for lower levels of contamination, and it is the most cost-effective alternative for this subgroup since only the principal threat volume is treated. Alternative 6b also reduces the overall remediation costs at RMA as the material removed from the sites within this subgroup is consolidated in the Central Processing Area before the installation of a cap/cover to provide fill for grading. As a result, the area to be maintained, as well as long-term monitoring and maintenance costs, are reduced.

The preferred alternative for the South Plants Tank Farm Subgroup is Alternative 16a: In Situ Physical/Chemical Treatment. This technology is effective in the removal of VOCs and is consistent with NCP guidance on treatment of more mobile contaminants. This alternative is also cost effective for the remediation of OCPs in surficial soils. In addition, Alternative 16a easily

compliments an in situ treatment alternative for groundwater or a groundwater pump-and-treat system for the South Tank Farm Plume.

The preferred alternative for the South Plants Balance of Area Subgroup is Alternative 6b: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Consolidation. This alternative is consistent with NCP guidance on the use of treatment for higher levels of contamination and on the use of engineering controls (containment) for lower levels of contamination, and it is cost effective. In addition, consolidation of material from this subgroup within the cap for the Central Processing Area reduces long-term management and maintenance activities.

The demolition of structures is required to allow the excavation of contaminated soils. The structural debris will be removed from the site along with any abandoned utilities encountered during excavation. Because the groundwater control systems selected for South Plants are in the South Plants Central Processing Area and South Plants Tank Farm Subgroups, the timing of soils remediation will be coordinated with the installation and operation of these groundwater systems.

#### 4.4.14 Buried Sediments/Ditches Medium Group

The preferred alternative for the Buried Sediments Subgroup is Alternative 6g: Caps/Covers with Consolidation. The consolidation of materials from this medium group into Basin A reduces long-term monitoring and maintenance at RMA compared to capping in place, as Basin A already includes a monitoring and maintenance program as part of the containment alternative. This alternative is consistent with NCP guidance on engineering controls for low levels of contamination, and it is cost-effective. Through contaminant removal and containment this alternative minimizes long-term adverse impacts at the site and improves the habitat.

The preferred alternative for the Sand Creek Lateral Subgroup is Alternative 6g: Caps/Covers with Consolidation. This alternative has a higher overall cost effectiveness than Alternative 3 as the contaminated soil (containing lower levels of contamination than Basin A) removed from

the Sand Creek Lateral sites will be used as a portion of the fill required to regrade Basin A for positive drainage prior to capping. In addition, long-term management and maintenance at RMA is reduced by consolidation of contaminated materials in Basin A (which includes a monitoring and maintenance program as part of its containment alternative) rather than capping in place. The preferred alternative allows the Sand Creek Lateral to continue to convey surface water, as it eliminates the potential for groundwater and surface-water contamination at the site. The selection of this alternative is consistent with the NCP (EPA 1990) regarding the use of engineering controls (containment) for low levels of contamination.

#### 4.4.15 Undifferentiated Medium Group

The preferred alternative for the Section 36 Balance of Area Subgroup is Alternative 6g: Caps/Covers with Consolidation. This alternative is cost effective for this subgroup as contaminated soils (containing lower levels of contamination than Basin A) are consolidated and contained at a location within 1 mile of the sites comprising this subgroup. The material excavated from this subgroup is used as part of the material required to regrade Basin A prior to capping. In addition, the alternative results in an overall cost reduction as long-term monitoring and maintenance are reduced through a decrease in the area that must be monitored at RMA. This alternative is consistent with NCP guidance on the use of engineering controls for lower levels of contamination. The structures within site CSA-2a will be demolished prior to treatment to allow access to the contaminated soils, and the structural debris will be removed from the site.

The preferred alternative for the Buried Trenches Subgroup is Alternative 3: Landfill. Since the area to be remediated has only low levels of contamination and large amounts of debris, this containment alternative is cost effective. Alternative 6: Caps/Covers has a lower cost, but requires the management of 160,000 SY of capped soils in various portions of the Eastern Study Area and restricts its use as habitat for burrowing animals. The selection of Alternative 3: Landfill is consistent with NCP guidance on the use of engineering controls for low levels of contamination.

### 4.4.16 Overview of Preferred Alternatives

On an RMA-wide basis, the preferred alternatives for soils form an overall alternative that is a combination of treatment, containment and institutional controls (Figure ES4.4-1), following the expectations of EPA as stated in the NCP (see Section 3.3.3.6). The preferred alternatives include 11 basic remedial approaches ranging from access restrictions to incineration (Table ES4.4-1). The cost of implementing these preferred alternatives is estimated to be approximately $530 million (this cost was developed for evaluating and comparing remedial alternatives and should not be interpreted as a design cost estimate for remedial actions).

In accordance with NCP expectations, the preferred alternatives consist of treating the principal threat areas (Figure ES4.4-2) to the maximum extent practicable. Approximately 750,000 bank cubic yards (BCY) of soils above the principal threats criteria are treated: 630,000 BCY by direct thermal desorption, 110,000 BCY by incineration, and 33,000 BCY by direct solidification/stabilization. The balance of the principal threat areas are addressed through engineering controls.

The preferred alternatives for the remaining soil medium groups/subgroups consist primarily of containment since these soils contain lower levels of contamination with lower long-term risks. Approximately 820,000 BCY of soils and debris are excavated and placed in the centralized on-post hazardous waste landfill. More than 1.5 million SY of soils are capped in place, and approximately 2.0 million BCY of soils are excavated and consolidated as grading fill prior to capping in Basin A and the South Plants Central Processing Area (Figure ES4.4-3).

In addition to thermal treatment and containment, institutional controls and pipe plugging were selected for the soils in the Sanitary/Process Water Sewers Subgroup due to the low levels of contamination, the existence of 6 to 8 feet of cover soils preventing exposure, and the ability of pipe plugging to reduce the potential for contaminant migration. Soil vapor extraction was selected for soils in the South Plants Tank Farm Subgroup due to the interaction of contaminated

groundwater with soils and the nature of the contamination. More than 7.5 million SY of surficial soils with low-level contamination will be treated by landfarming/agricultural practices.

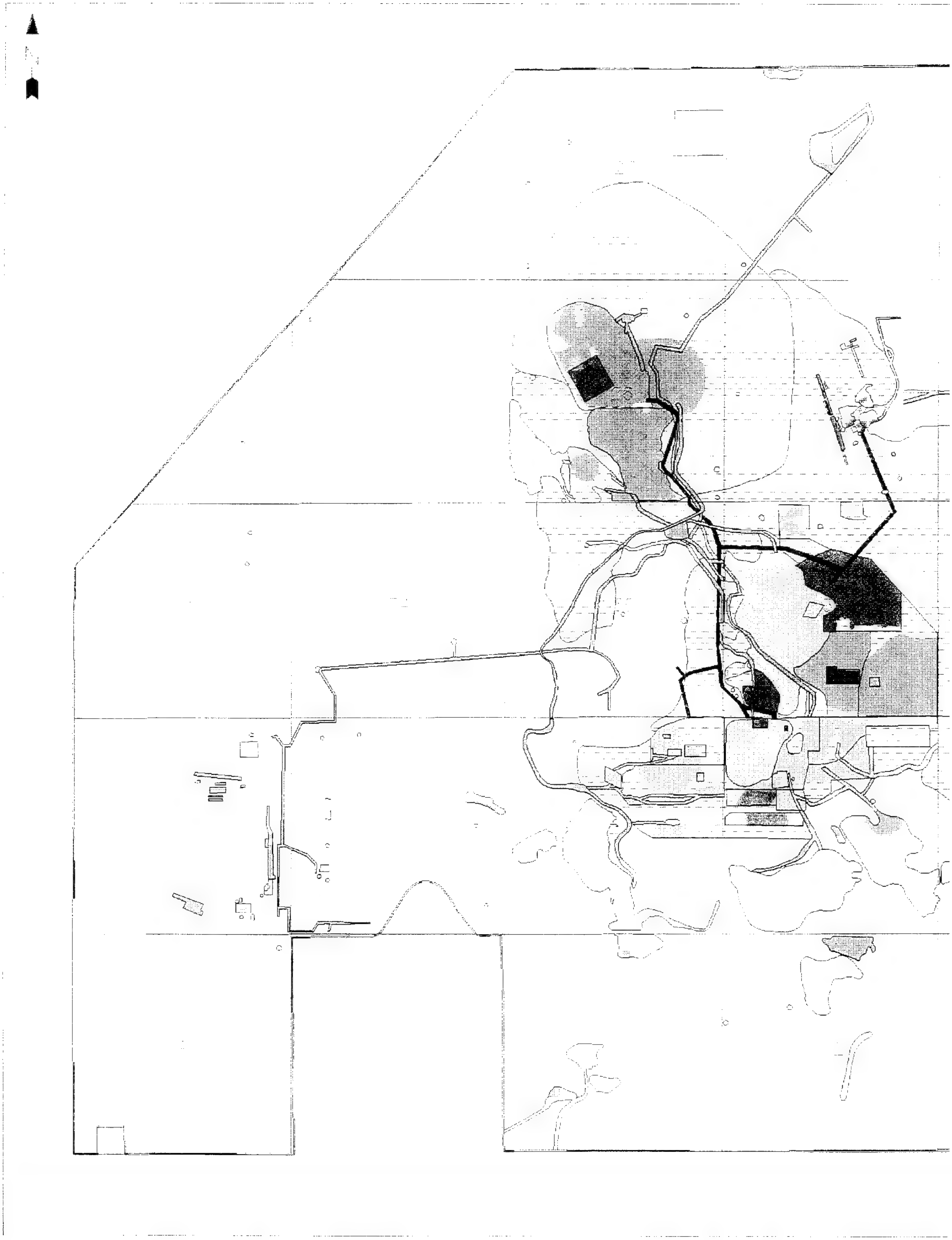
Table ES4.4-1 Preferred Alternatives for the Soils Medium 

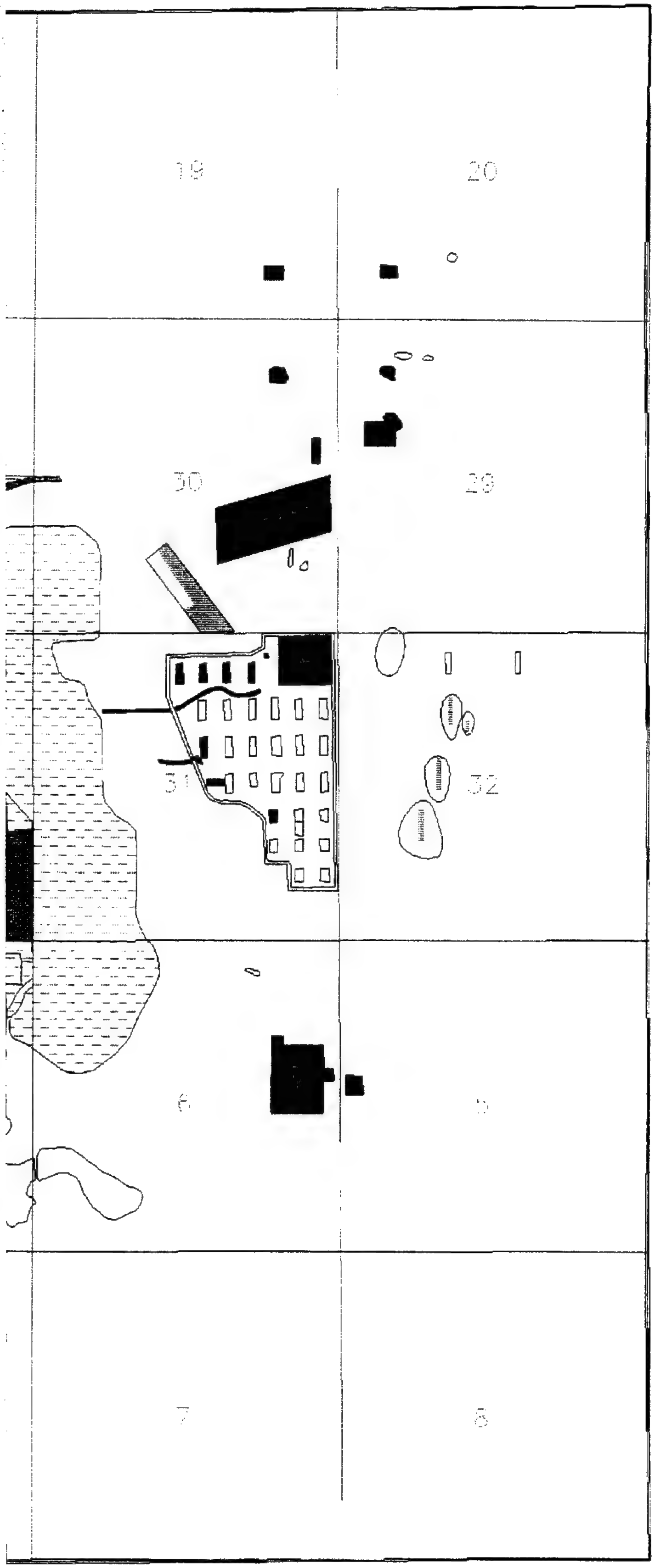
| Medium Group/Subgroup | Army Preferred Alternative | Total Cost ($ Million) | Present Worth Cost[1] ($ Million) |
|---|---|---|---|
| **Human Health** | | | |
| Basin A | Direct Thermal Desorption of Principal Threat Volume; Caps/Covers | 56 | 39 |
| Basin F Wastepile | Caps/Covers | 12 | 9.2 |
| Secondary Basins | Caps/Covers with Consolidation | 12 | 12 |
| Former Basin F | Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Modifications to Existing System | 98 | 82 |
| Basin F Exterior | Caps/Covers with Consolidation | 6.0 | 5.6 |
| Sanitary/Process Sewers | Access Restrictions | 4.8 | 3.6 |
| Chemical Sewers | Direct Thermal Desorption of Principal Threat Volume; Landfill | 19 | 17 |
| Complex Trenches | Caps/Covers; Vertical Barriers with Consolidation | 37 | 30 |
| Shell Trenches | Incineration/Pyrolysis; Landfill | 100 | 94 |
| Hex Pit | Incineration/Pyrolysis; Landfill | 3.7 | 3.5 |
| Sanitary Landfills | Landfill | 32 | 29 |
| Lime Basins | Direct Thermal Desorptio of Principal Threat Volume; Caps/Covers; Vertical Barriers with Modifications to Existing System | 6.5 | 4.9 |
| Buried M1 Pits | Direct Solidification/Stabilization | 5.1 | 4.3 |
| South Plants Central Processing | Direct Thermal Desorption and Direct Solidification/Stabilization of Principal Threat Volume; Caps/Covers | 100 | 91 |
| South Plants Ditches | Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Consolidation | 7.7 | 7.0 |
| South Plants Tank Farm | In Situ Physical/Chemical Treatment | 9.5 | 8.0 |
| South Plants Balance | Direct Thermal Desorption of Principal Threat Volume; Caps/Covers with Consolidation | 32 | 29 |
| Buried Sediment | Caps/Covers with Consolidation | 6.1 | 6.1 |
| Sand Creek Lateral | Caps/Covers with Consolidation | 1.5 | 1.5 |
| Section 36 Balance | Caps/Covers with Consolidation | 25 | 22 |
| Burial Trenches | Landfill | 7.4 | 6.5 |
| | Subtotal | | |
| **Biota** | | | |
| Surficial Soils | In Situ Biological Treatment | 3.7 | 2.8 |
| Lake Sediments | Caps/Covers with Consolidation; No Additional Action | 7.7 | 5.7 |
| Ditches/Drainage Areas | Caps/Covers with Consolidation | 1.1 | 1.1 |
| | Subtotal | | |

Table ES4.4-1 Preferred Alternatives for the Soils Medium 

| Medium Group/Subgroup | Army Preferred Alternative | | Total Cost ($ Million) | Present Worth Cost[1] ($ Million) |
|---|---|---|---|---|
| Agent Storage | | | | |
| North Plants | Incineration/Pyrolysis | | 0.4 | 0.4 |
| Toxic Storage Yards | Incineration/Pyrolysis | | 3.2 | 3.1 |
| | | Subtotal | | |
| UXO | | | | |
| Munitions Testing | Incineration/Pyrolysis | | 8.0 | 7.4 |
| | | Subtotal | | |
| Total for Soils Medium | | Total | 610 | 530 |

1 Cost Represents Total Present Worth Cost in Millions (1995 Dollars)






## Legend

- Arsenal Boundary
- Incineration
- Thermal Desorption of Principal Threat Volumes; Caps/Covers[1]
- Thermal Desorption of Principal Threat Volumes; Consolidation
- Direct Solidification/Stabilization
- Caps/Covers
- Consolidation
- Thermal Desorption of Principal Threat Volumes; Landfill
- Landfill
- Soil Vapor Extraction
- In Situ Agricultural Practices
- Access Restrictions
- SARsite Boundary
- 5 Section Number

[1]Solidification/Stabilization included for Principal Threat Vloume with Inorganic Exceedance for South Plants Central Processing Area

1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure ES4.4-1

Summary of Preferred Soils Alternatives

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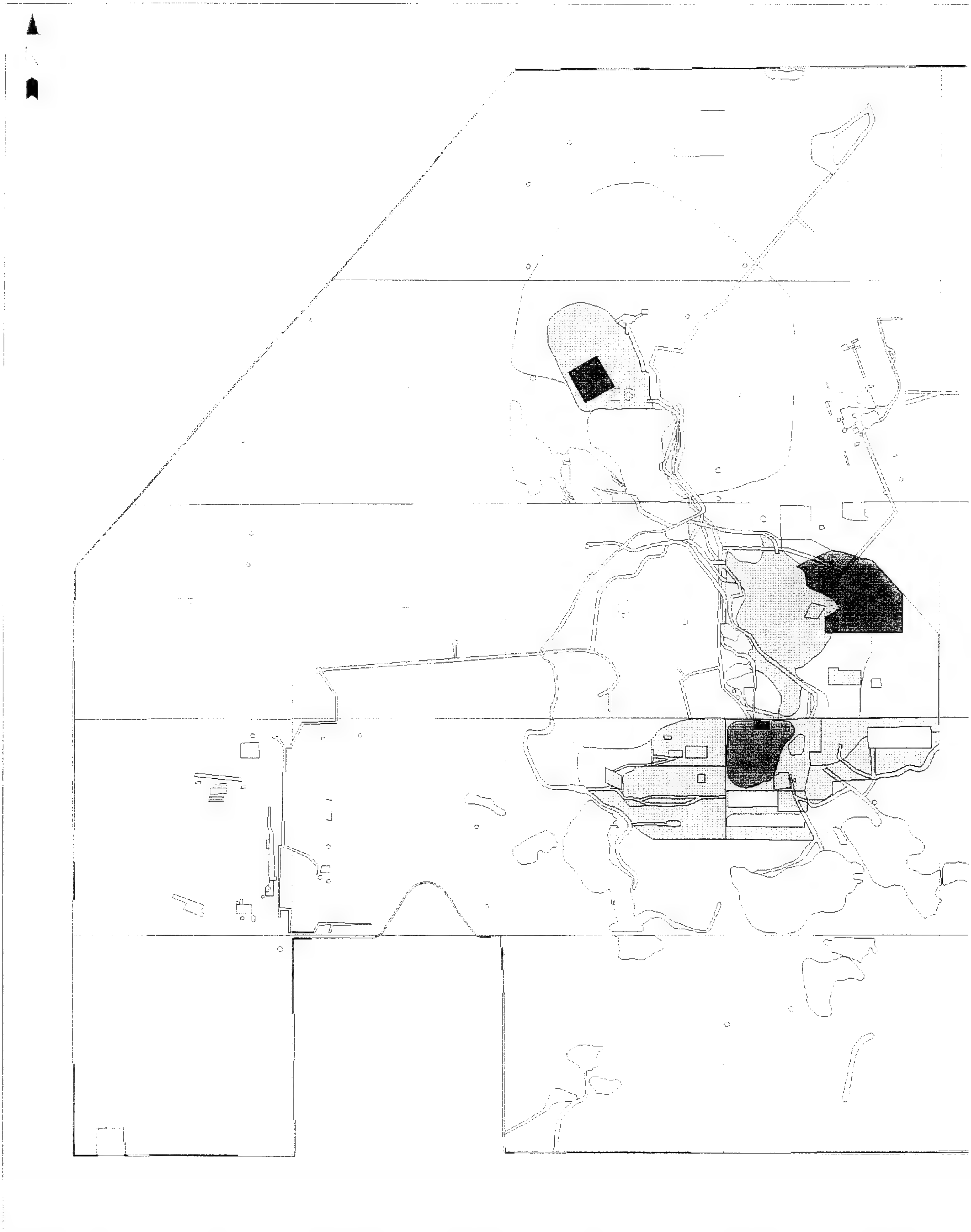

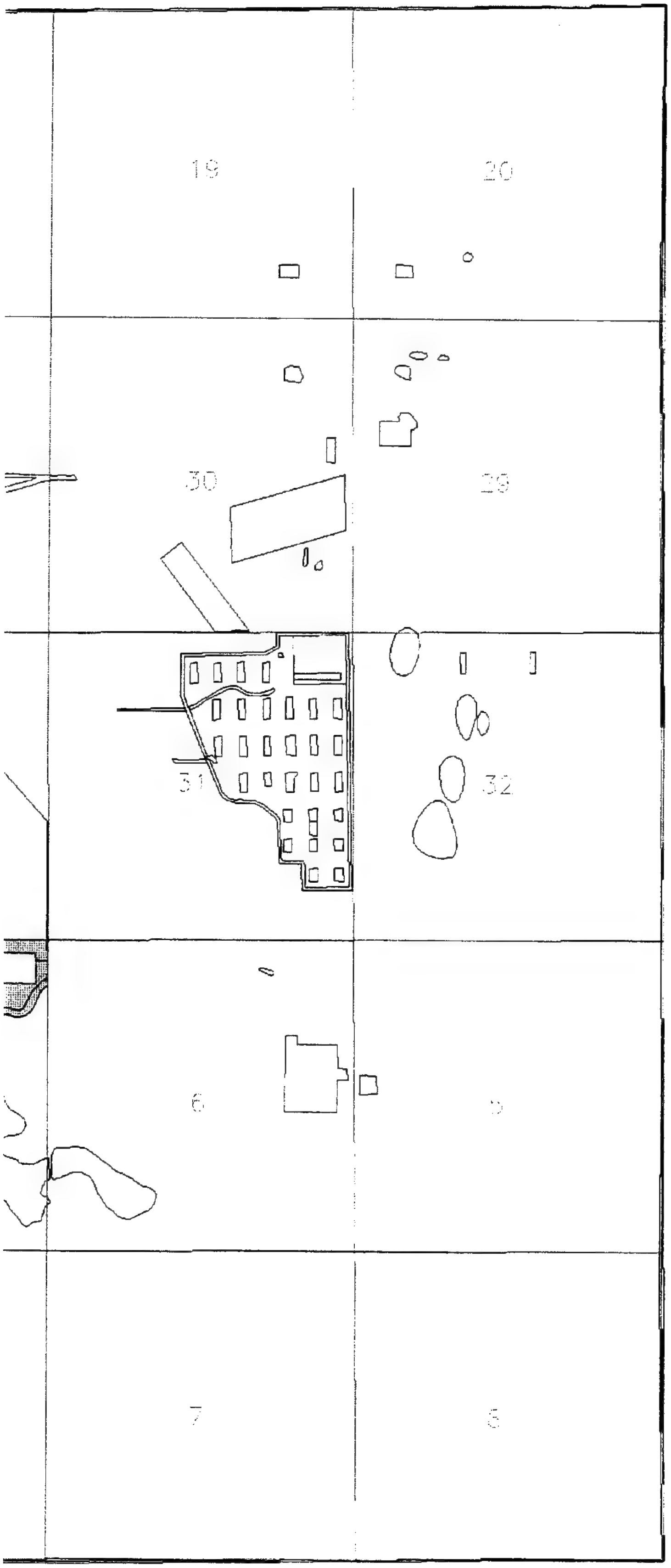


Legend

- Arsenal Boundary
- Thermal Desorption of Principal Threat Area
- Direct Solidification of Principal Threat Area
- Thermal Desorption and Direct Solidification of Principal Threat Area
- Cap/Cover of Principal Threat Area
- SARsite Boundary
- 5 Section Number

1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure ES4.4-2

Preferred Principal Threat Alternatives

(Note: Entire Site Shown)

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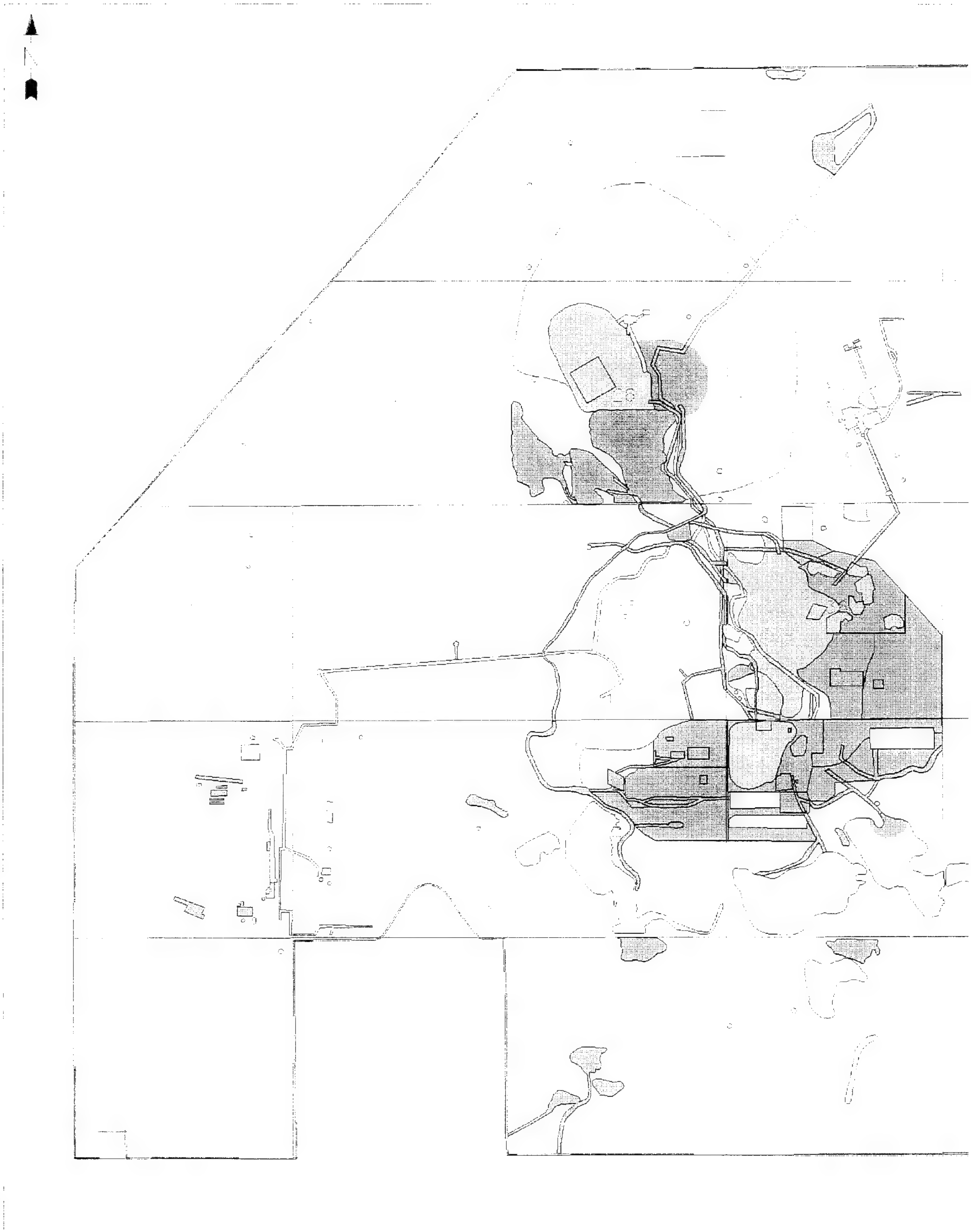
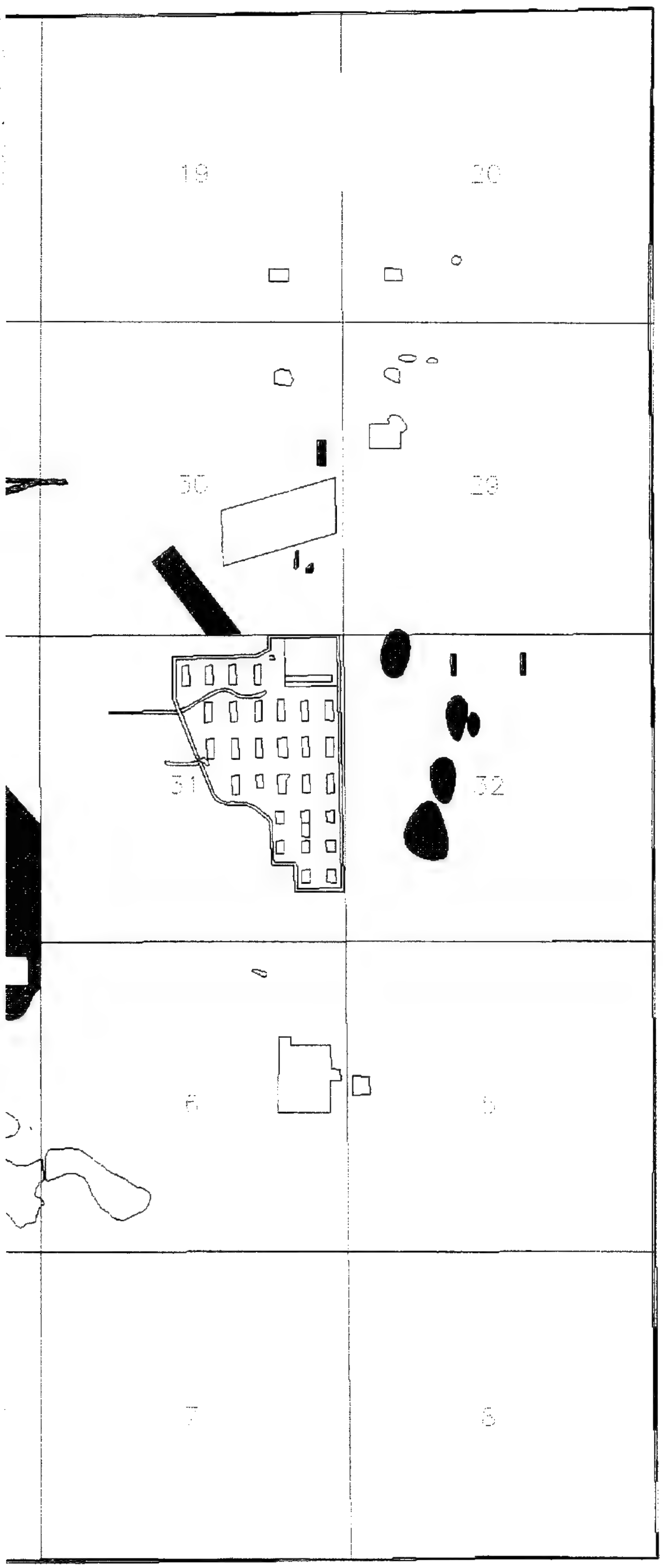





## Legend

Arsenal Boundary

Landfil

Consolidation to Landfill

Capping

Excavation/Consolidation to Capped Areas

SARsite Boundary

5 Section Number

1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure ES4.4-3

Containment Alternatives

(Note: Entire Site Shown)

Ebasco Services Incorporated
June 1993

## 5.0 SUMMARY OF THE DETAILED ANALYSIS OF ALTERNATIVES FOR WATER

### 5.1 ORGANIZATION

The Water DAA Report is presented in one volume. Sections 1.0 through 3.0 provide an introduction to the Water DAA and a discussion of the methodology used throughout the volume. Sections 4.0 through 8.0 present the detailed analysis of alternatives for each plume group. Section 9.0 summarizes the results of the Water DAA and presents the preferred alternative for each plume group. Section 10.0 discusses the potential for combined treatment in the South Plants and Basin A area. Appendix A presents the detailed cost tables for each alternative.

### 5.2 WATER DAA APPROACH

The FFA specifies that the point of compliance for on-post contaminated groundwater is at the boundary of RMA, and the currently operating boundary systems are in compliance with off-post PRGs. Therefore, on-post groundwater extraction and treatment internal to the boundaries was considered in the DAA primarily for the purpose of contaminant mass reduction and lowering the water table (dewatering) in conjunction with soil remedial alternatives.

The Water DSA identified 15 individual plumes that were combined into 5 plume groups (Figure ES5.2-1). A range of alternatives including no action, containment, and treatment options was retained in the DSA for three of the plume groups. Two plume groups (Northwest Boundary Plume Group and Western Plume Group) did not have sufficient contamination concentrations to warrant containment or treatment actions beyond those already in place at the RMA boundary or as a result of on-post interim response actions (IRAs).

#### 5.2.1 Plume Evaluation Criteria

Plume evaluation criteria (PECs) were developed to determine whether a plume warranted further consideration in the DAA. The PECs are contaminant indicator levels that are used as a screening tools in determining whether additional control or treatment should be considered in light of the RAOs for groundwater and the existing IRAs and boundary control systems. The PEC values are ten times the drinking water standards or risk-based valves, or off-post PRGs.

### 5.2.2 Target Effluent Criteria

As a result of the DSA dispute resolution, it was agreed that target effluent criteria (TECs) would be determined for each internal groundwater treatment system, and that the TECs would be enforceable groundwater reinjection standards that will be specified in the ROD. After evaluating the groundwater plumes and the proposed treatment systems, proposed TECs were developed for alternative detailing and costing in the DAA for two plume groups, the Basin A and South Plants plume groups. Because these plumes are internal to RMA and treated water will be reinjected on post, with another opportunity for treatment at the boundary systems, the TECs for these plume groups were set at twice the off-post PRGs or drinking water standards (where such exist). However, TECs for the remaining plume groups were established as the off-post PRGs, as they use existing boundary systems. As stated above, the TECs will be reviewed as the DAA proceeds and be finalized in the ROD.

### 5.2.3 Design Treatment Goals

Design treatment goals (DTGs) were established as guidance concentration values for design of on-post treatment systems. These concentrations represent drinking water standards or off-post PRGs but are not enforceable. Each system is designed to meet DTGs, but will only be required to meet the TECs, which are twice the DTG values. DTGs are for internal RMA systems only as boundary systems must meet established PRGs.

### 5.2.4 Groundwater Data Update

New groundwater monitoring data were incorporated into the database used during the Water DSA to evaluate the plumes against the PEC, to update plume contaminant concentrations. Additional statistical analysis of the most recent chemical data (1988–92) resulted in decreased contaminant concentrations compared to those previously estimated in the DSA.

### 5.2.5 Subregional Groundwater Modeling

Groundwater flow modeling was performed for the Basin A and South Plants areas to assist in the evaluation of remedial alternatives in the DAA. This work is presented under separate cover

(EBASCO 1993). In addition, flow information was obtained from analytical estimates for the Basins C and F area. Groundwater modeling results typically show significantly lower flow rates in most plumes as compared to previous DSA estimates. These flow rates were incorporated into the proposed on-post groundwater control and treatment systems. Lower groundwater extraction rates combined with lower contaminant concentration estimates led to some reconfigurations of the groundwater extraction and treatment systems presented in the DSA.

### 5.2.6 Phasing of Groundwater Remedial Activities

In the DAA, alternatives developed for the soils medium that potentially could affect groundwater remediation (and vice versa) were evaluated with respect to the timing and selection of water remedial alternatives. The selected alternative for water in the South Plants Plume Group includes contaminant mass removal and dewatering, and while mass removal in the South Tank Farm area can be accomplished during soils and structures remedial activities, in the South Plants Central processing area it is impractical to install a dewatering well network until the structures and soils alternatives are completed and the cap is installed over the area. Thus, the selected alternative for the South Plants Plume Group involves a mass removal system operating for 10 years, and the implementation of a dewatering system only after the South Plants soils and structures remedial activities are complete. Since the South Plants groundwater elevations are falling and will be further reduced as a result of soils remedial activities (local dewatering and capping) the final design and extent of the dewatering system will be established following completion of soils and structures remediation.

### 5.2.7 Combined Treatment Alternatives

RMA is unique in that currently there are eight pre-ROD operational water treatment systems. These are the Irondale Containment System, the Northwest Boundary Containment System, the North Boundary Containment System (NBCS), the Basin A Neck IRA, the Basin F Groundwater IRA, the Motorpool and Railyard IRAs, and the CERCLA Wastewater Treatment Plant. Alternatives developed in the DSA included similar systems to these existing systems. In the DAA, treatment alternatives incorporated existing treatment systems, if possible, to reduce the

need for construction and operation of new treatment plants requiring additional operators and equipment. The Basin A and South Plants plume groups both include air stripping and granular activated carbon (GAC) adsorption as the selected treatment alternative. The groundwater produced by the Basin A and South Plants preferred alternatives is treated by a combined Basin A/South Plants treatment plant. However, during the remedial design, a determination will be made as to the available capacity of the CERCLA Wastewater Treatment Plant to determine whether it can handle the projected waste stream, if modifications to the existing system should be made, or if a new treatment system must be constructed.

## 5.3 EVALUATION OF ALTERNATIVES

As with soils and structures, all water alternatives were evaluated in accordance with the DAA criteria described in Section 3.0 of this document. Once each alternative was analyzed (Sections 4.0 through 8.0 of the Water DAA), it was compared to all the other alternatives for the same plume group using the DAA evaluation criteria. In particular, the added benefits of on-post groundwater treatment alternatives were evaluated in light of the existing boundary systems.

## 5.4 SELECTION OF PREFERRED ALTERNATIVES

Following the comparative analysis of alternatives for the five plume groups, a selection of the preferred alternative was accomplished based on the following plume-specific factors:

- Contamination levels present in the plume
- Existing control and treatment of the plume
- Source control actions selected for the overlying soils
- Potential impact on the existing boundary control and treatment systems

The following subsections describe the alternatives selected for each plume group, which are summarized in Table ES5.4-1 and shown in Figure ES5.4-1.

### 5.4.1 Western Plume Group

Alternative WC-2: Continued Existing Action: Continued operation of the Irondale Control System as well as the Motor Pool and Railyard IRAs with appropriate monitoring and modification, if needed, to ensure that off-post PRGs are met. No additional action is undertaken.

### 5.4.2 Northwest Boundary Plume Group

Alternative NWC-2: Continued Existing Action: Continued operation of the Northwest Boundary Containment System with appropriate monitoring and modification, if needed, to ensure that off-post PRGs are met. No additional action is undertaken.

### 5.4.3 North Boundary Plume Group

Alternative NC-2: Continued operation of North Boundary Containment System (NBCS) and the Basin F Groundwater IRA with appropriate monitoring and modification, if needed, to ensure that off-post PRGs are met. No additional action is undertaken.

### 5.4.4 Basin A Plume Group

Alternative AC-3/AT-2: Mass Reduction, Stripping/Sorption includes the installation of a mass removal system to optimize contaminant mass removal from within the Basin A Plume. This system is anticipated to operate for 10 years and is combined with the selected soils alternative to cap significant portions of Basin A. Water pumped from the mass removal system will be treated in the combined South Plants/Basin A treatment plant as described in Section 10.0 of the Water DAA. The Basin A Neck IRA continues to operate to minimize contaminant migration.

### 5.4.5 South Plants Plume Group

Alternative SPC-7/SPT-2/SPT-5: Mass Reduction/Dewatering/Cap, Stripping/Sorption, In Situ Biodegradation includes a phased approach to groundwater extraction and treatment in South Plants. During the first 10 years (Phase I), an in situ biotreatment system is installed in the

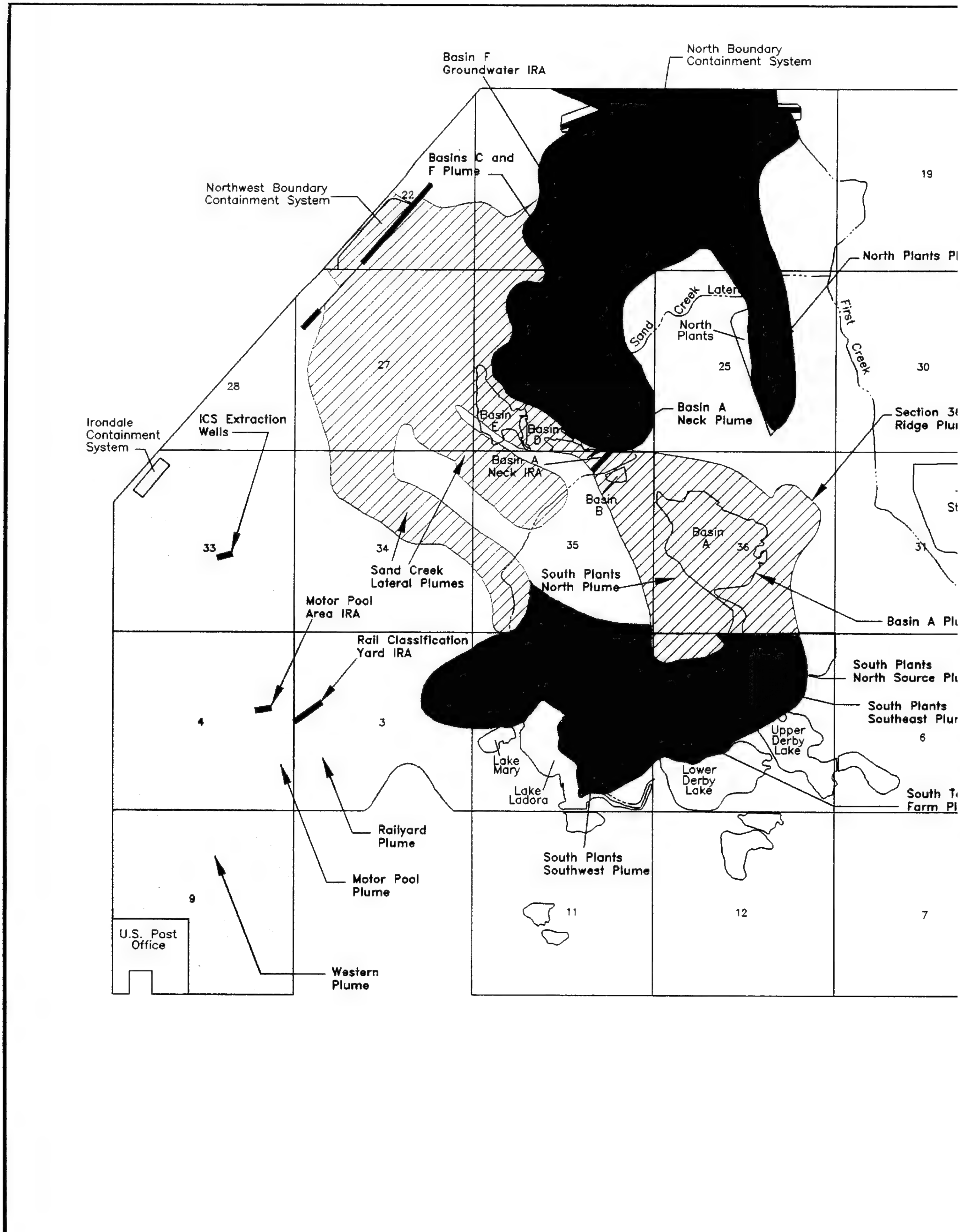
South Plants South Tank Farm plume to treat high levels of benzene. A low volume of water is extracted from the South Plants North Source Area and the southeast Plumes and treated with Basin A groundwater during the same time period. Light nonaqueous phase liquids (LNAPLs) will be removed through dual pump separation during the first 5 years of operations. Following the first 10 years, a dewatering grid is established, in conjunction with the capping of the South Plants Central Processing Area (the soils preferred alternative) to effectively isolate the remaining contaminants and to prevent migration away from South Plants. The dewatering grid uses mass removal wells where possible. All water generated from the mass removal and dewatering systems is treated at a combined South Plants/Basin A treatment plant as described in Section 10.0 of the Water DAA.

Table ES5.4-1 Preferred Alternatives for the Water Medium 

| Medium Group/Subgroup | Army Preferred Alternative | Cost[1] ($ Million) |
|---|---|---|
| Northwest | Continued Existing Action (Northwest Boundary Containment System) | $22 |
| Western | Continued Existing Action (Irondale Control System) | $16 |
| North Boundary | Continued Existing Action (North Boundary Containment System) | $44 |
| Basin A | Mass Reduction, Capping of Basin A (Soils Alt.) with Continued Control and Treatment at the Basin A Neck IRA* | $30 |
| South Plants | Mass Reduction, In Situ Bio Treatment of South Tank Farm Plume, Capping of South Plants Central Processing Area, Dewatering System for the South Plants Groundwater Mound | $21 |
| Total for Water Medium | Total | $133 |

1 Cost Represents Total Present Worth Cost in Millions (1995 Dollars)

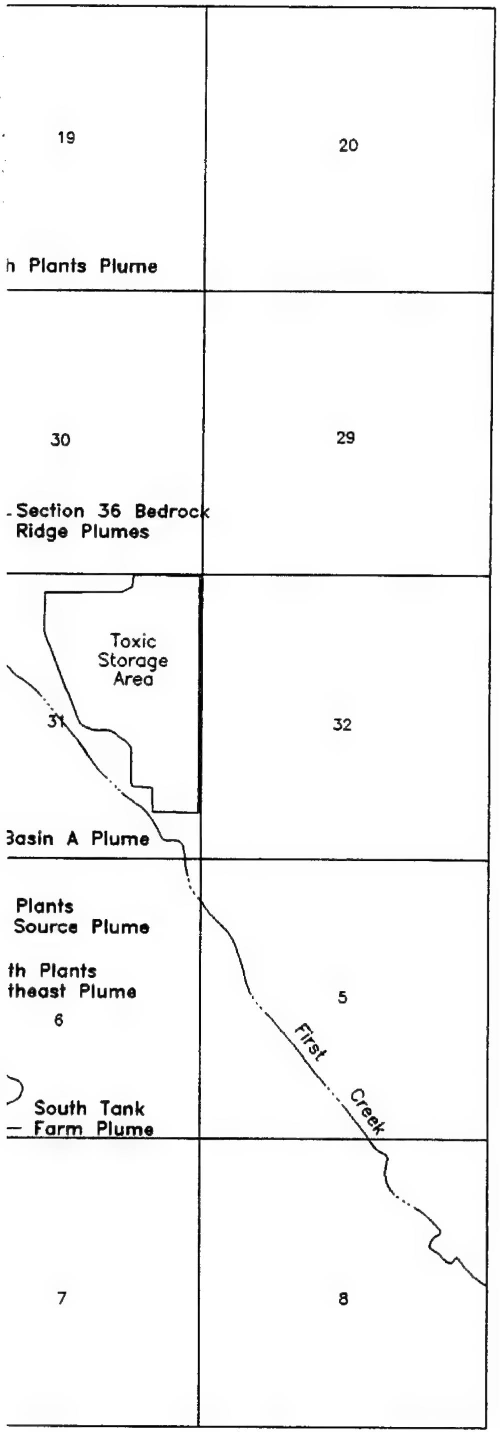
* Capping costs are not included in this estimate but are estimated and described in the Soils DAA.

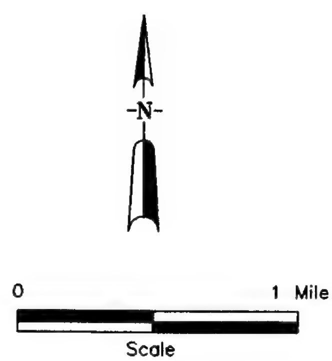


Basin F
Groundwater IRA
North Boundary
Containment System
Basins C and
F Plume
Northwest Boundary
Containment System
22
19
North Plants Pl
Sand Creek Later
First Creek
North
Plants
27
25
30
28
Irondale
Containment
System
ICS Extraction
Wells
Basin
E
Basin
D
Basin A
Neck Plume
Section 3
Ridge Plu
Basin A
Neck IRA
Basin
B
St
Basin
A
33
34
35
36
31
Sand Creek
Lateral Plumes
South Plants
North Plume
Basin A Pl
Motor Pool
Area IRA
Rail Classification
Yard IRA
South Plants
North Source Pl
South Plants
Southeast Plur
4
3
Upper
Derby
Lake
6
Lake
Mary
Lake
Ladora
Lower
Derby
Lake
South T
Farm Pl
Railyard
Plume
South Plants
Southwest Plume
Motor Pool
Plume
9
11
12
7
U.S. Post
Office
Western
Plume

LEGEND

- North Boundary Plume Group
- Northwest Boundary Plume Group
- Western Plume Group
- South Plants Plume Group
- Basin A Plume Group
- Line of Extraction Wells
- WES Model Boundary
- DAA Model Boundary



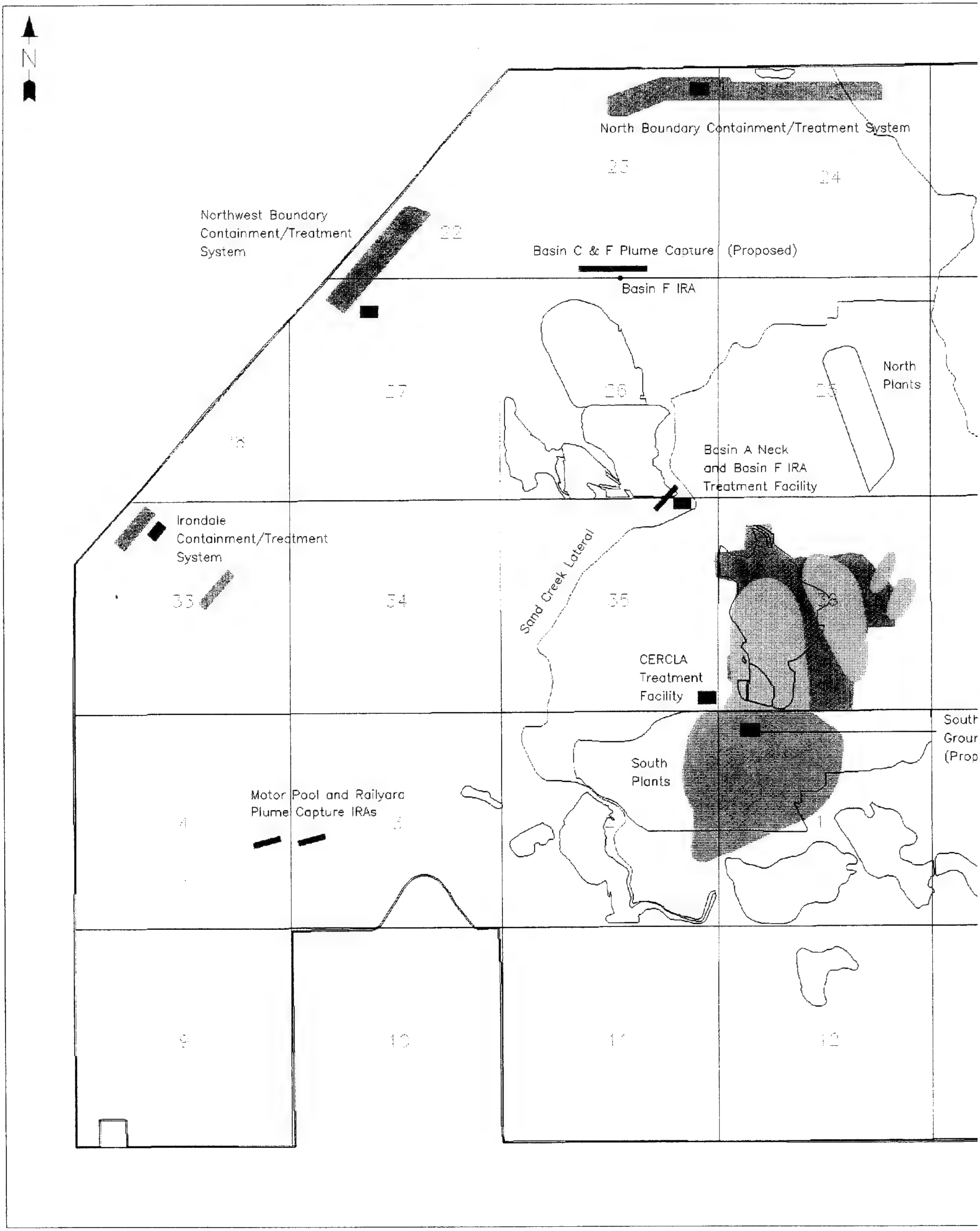




SOURCE: Water DSA Plume Map

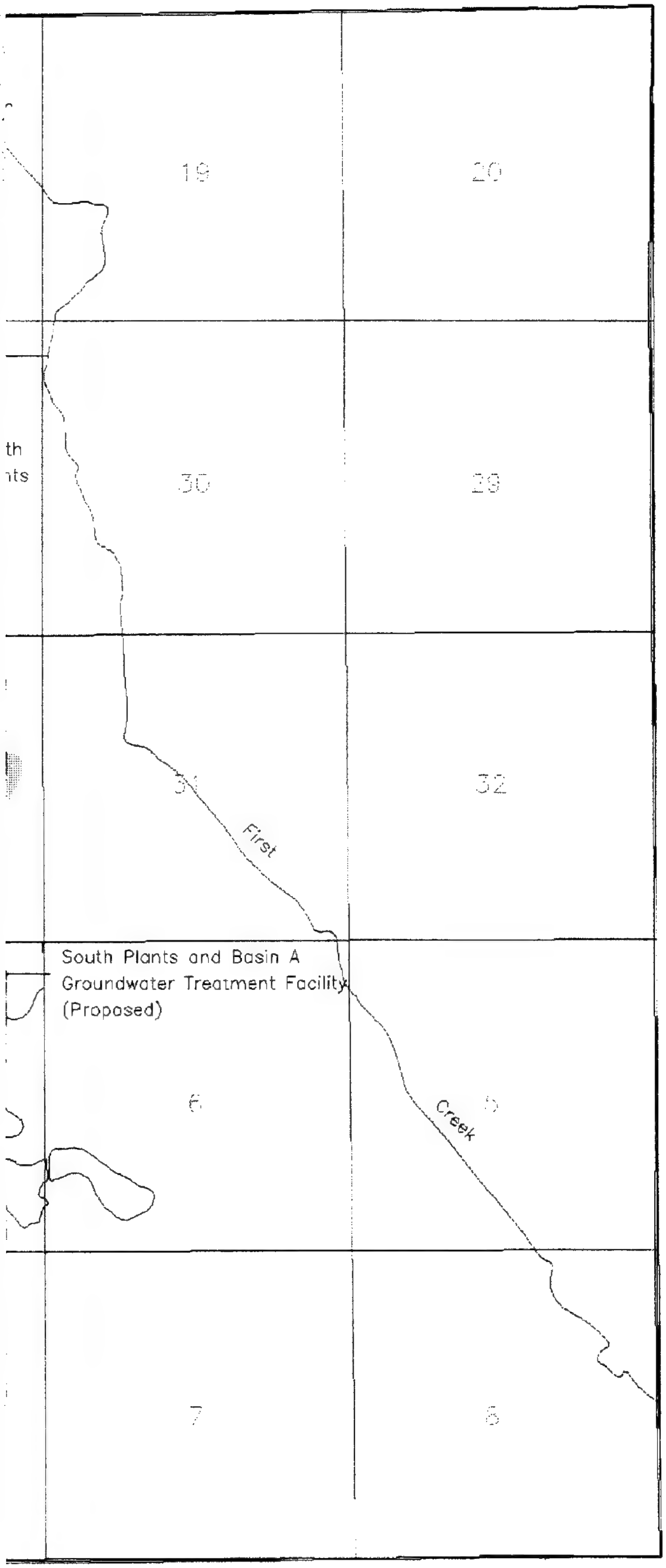
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

FIGURE **ES5.2-1**
Historical Total Organic Plumes for
Unconfined Flow System (from DSA)

Prepared by:
EBASCO SERVICES INCORPORATED



N
North Boundary Containment/Treatment System
23
24
Northwest Boundary Containment/Treatment System
22
Basin C & F Plume Capture (Proposed)
Basin F IRA
North Plants
27
26
25
Basin A Neck and Basin F IRA Treatment Facility
Irondale Containment/Treatment System
Sand Creek Lateral
33
34
35
36
CERCLA Treatment Facility
South Plants
Motor Pool and Railyard Plume Capture IRAs
4
3
2
1
9
10
12




Legend

- Arsenal Boundary
- SARsite Boundary
- Boundary Systems
- Treatment Systems
- Motor Pool and Railyard Plume Capture IRAs
- Basin F IRA; Basins C & F Plume Capture
- Basin A Neck IRA
- Basin A Cap
- Basin A Plume Group Mass Removal
- South Plants Plume Group Mass Removal, In Situ Biotreatment, Dewatering, and Capping
- 5 Section Number

1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for
Rocky Mountain Arsenal

Figure ES5.4-1

Preferred Water Alternatives

Ebasco Services Incorporated
July 1993

## 6.0 SUMMARY OF THE DETAILED ANALYSIS OF ALTERNATIVES FOR THE STRUCTURES MEDIUM

### 6.1 ORGANIZATION

The Structures DAA Report is presented in one volume. Sections 1.0 through 3.0 provide an introduction to the Structures DAA, a discussion of the methodology used throughout the volume, and a discussion of the medium groups established for the structures medium. Sections 4.0 through 8.0 present the detailed analysis of alternatives for each of the structures medium groups. Section 9.0 summarizes the results of the Structures DAA and presents the preferred alternative for each medium group. Appendix A presents the lists of structures by medium group while Appendix B details the estimates of structural material volumes and areas. Appendix C presents the detailed cost tables for each alternative.

### 6.2 STRUCTURES DAA APPROACH

To facilitate the development and analysis of alternatives, four structures medium groups were developed during the DSA: Future Use, No Potential Exposure; No Future Use, Nonmanufacturing History; No Future Use, Manufacturing History; and No Future Use, Agent History. As is evident from these titles, structures were grouped based on similar use histories so that similar remedial options could be more efficiently applied and evaluated for each of the 986 structures at RMA. The medium group of No Future Use, Manufacturing History was further divided in the DAA to include two subgroups, Process History Structures and Non-Process History Structures, which more accurately reflects their use history.

As part of the DAA process, the alternatives developed and retained in the DSA were examined to determine whether any of the rejected alternatives should be re-evaluated or whether any of the retained alternatives should be modified. The rationale for changing the list of retained alternatives was based on several factors including changes in site conditions, changes in information regarding structures, changes in information concerning technologies contained in the retained alternative, changes in regulations, and changes in interaction with other media.

Three alternatives retained in the DSA were modified in the DAA for the No Future Use, Manufacturing History Medium Group to provide additional flexibility in the selection of the preferred alternative due to media interactions, new technology information, or revised structures information. Alternative 18 (Dismantling, Peroxide/Hypochlorite Treatment, On-Post Hazardous Waste Landfill), although rejected in the DSA, was re-evaluated for the No Future Use, Agent History Medium Group in the DAA due to new technology information, and Alternative 18a which added in situ sand blasting to treat other contaminants in addition to Army agent, was developed and evaluated.

## 6.3 EVALUATION OF ALTERNATIVES

Details on technologies and processes used to address structural contamination is contained in the Technology Description Volume. The Task 24 Structures Survey Report was used to provide additional detail in the form of structural material quantity estimates to complete more detailed and accurate cost estimates for alternative evaluation. Survey information was not available for the 42 structures that have been constructed since the Task 24 report, but initial estimates indicate that these additional structures will not significantly impact the cost estimates. Appendix B contains detailed information of volume and area calculations.

As discussed in the DSA report, the selected alternatives for the soils medium influence and, in many cases, dictate the selection of alternatives for the structures medium. For example, no action and institutional controls alternatives were not considered acceptable for structures medium groups where soils excavation and capping alternatives were selected for contaminated soils in the vicinity of (and potential beneath) structures. An additional alternative, Alternative 21a (demolition/consolidation), was also developed for the structures medium groups to be consistent with similar alternatives developed for the soils medium groups.

## 6.4 SELECTION OF PREFERRED ALTERNATIVES

Following the comparative analysis of alternatives, and taking into account soils interactions, a preferred alternative was selected for the structures medium groups. As stated in the DSA, the

Future Use, No Potential Exposure and the No Future Use, Nonmanufacturing History Medium Groups are considered to be outside the CERCLA process due to their location and use history. No CERCLA action was selected for these medium groups and they were not evaluated in the DAA.

For the remaining medium groups and subgroups, the preferred alternative consists of demolition of all structures within that group. For both subgroups under the No Future Use, Manufacturing History Medium Group, Alternative 21a (Salvage, Demolition, Consolidation) was selected as the preferred alternative. This alternative removes all structural material from the site (which provides the necessary access for soils alternatives) and consolidates the rubble in Basin A as grading fill prior to the capping of Basin A. For the No Future Use, Agent History Medium Group, Alternative 18 (Demolition, Caustic/Hypochlorite Wash, and Landfill) was selected as the preferred alternative. This alternative provides the necessary documentation to satisfy the chemical weapons treaty and to adequately protect human health and the environment. Table ES6.4-1 lists the costs for the preferred alternatives.

Table ES6.4-1 Preferred Alternatives for the Strucutres Medium



| Medium Group/Subgroup | Army Preferred Alternative | Cost[1] ($ Million) |
|---|---|---|
| No Future Use - Manufacturing–Process History Subgroup | Salvage, Demolition, Consolidation of Structural Debris in Basin A as Grading Fill Prior to Capping | $36 |
| No Future Use - Manufacturing–Non-Process History Subgroup | Salvage, Demolition, Consolidation of Structural Debris in Basin A as Grading Fill Prior to Capping | $11 |
| No Future Use - Agent History | Demolition, Treatment of Agent Contaminated Structural Debris with Caustic, Disposal in On-Site Hazardous Waste Landfill | $58 |
| Structures IRAs | Asbestos/PCB Removal | $30 |
| | Non Agent Process Equipment Removal | $20 |
| | Agent Process Equipment Removal | $50 |
| | Tank Removal | $30 |
| Total for Structures Medium | Total | $240 |

1 Cost Represents Total Present Worth Cost in Millions (1995 Dollars)

## 7.0 SUMMARY

In the DSA phase of the FS, a range of remedial alternatives was developed and screened for each medium group within each contaminated medium. Included in this range were "no additional action" alternatives, institutional controls alternatives, containment alternatives, treatment alternatives, and alternatives that combined both treatment and containment. The alternatives developed in the DSA were modified as necessary to meet site-specific conditions and considerations, described in additional detail to allow evaluation against the DAA criteria specified by EPA (EPA 1988). These alternatives were then compared to select the preferred alternatives as the final step of the FS.

As described in EPA's "A Guide to Selecting Superfund Remedial Actions" (EPA 1990) and in accordance with Section 121 of CERCLA, selected alternatives must:

1. Protect human health and the environment
2. Comply with applicable or relevant and appropriate requirements (ARARs) unless a waiver is justified
3. Be cost-effective
4. Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
5. Satisfy the preference for treatment as a principal element or provide an explanation in the ROD why the preference was not met.

As described in Section 2.2 of the Executive Summary, numerous response actions have been implemented or currently are being implemented which are consistent with the requirements listed above. These interim response actions, while not developed as part of the on-post FS, contribute significantly to the cleanup of some of the most serious contamination problems at RMA. As such, the FS carefully considered these actions in the development and analysis of remedial alternatives to determine if sufficient remedial response had been implemented to meet the criteria listed above, and whether additional action was required or appropriate.

To meet the statutory requirements under CERCLA and the FFA for all medium groups within the soils, water, and structures media while considering the existing response actions, an overall strategy for cleanup was developed. This strategy involves modifying or supplementing existing remedial actions where possible (i.e., modify the CERCLA wastewater treatment facility, supplement the Basin F wastepile cap with an additional RCRA cap, etc) to enhance the remediation that was already implemented through the IRA process. For contaminated areas not already addressed by existing systems or IRAs, or where additional remedial actions were appropriate, the remediation strategy emphasized EPA's preference for treating, where practicable, the contaminated material posing the highest potential risks, or principal threats, with containment and/or less aggressive treatment for the remainder of the area. In addition, the alternatives were designed to minimize the areas that would require long-term maintenance and monitoring while maximizing the areas available to wildlife and the general public for wildlife refuge use. A similar strategy also was applied to the water medium, in which the "hot spot" portions of plumes in the central portion of RMA would be extracted and treated, with the remainder of the plumes being treated by the existing on-post internal and boundary systems. The groundwater extraction systems in the "hot spot" areas coincide with containment alternatives for soils and structures, creating a combined containment/treatment overall strategy. It is recognized that remedial alternatives involving more extensive treatment, or less aggressive treatment and more containment, may also fulfill the statutory requirements of CERCLA. However, the strategy selected for RMA provides a balanced approach to risk reduction through treatment and containment.

It should be noted that this overall strategy is modified in many instances by site-specific considerations. For example, for some "hot spot" areas, containment is preferred over removal and treatment of waste due to the hazards associated with excavation, handling, or treatment particularly where there is a potential for UXO or agent. At other sites with similar contamination levels, treatment may be selected due to lower risks of excavation, handling, or treatment. For the structures medium, demolition and removal may be selected to prevent future

risks related to deterioration of buildings, even when it may not be required due to contamination.

The costs associated with remediation of RMA may vary widely depending on the remedial strategy selected. For example, an approach based on enhanced containment alternatives for the remediation of soils and structures, with continued groundwater extraction and treatment, is estimated to cost a total of approximately $1.6 billion (in 1995 dollars using a present worth evaluation method), including existing and planned response actions, current activities at RMA, and future management and cleanup costs. The current strategy outlined in the DAA is estimated to cost a total of approximately $2.1 billion. If all exceedances were addressed by aggressive treatment (e.g., incineration/thermal desorption of all soil exceedances and manufacturing/agent history structures) the total remediation costs for RMA could exceed $4 billion.

The alternatives selected for each of the media are presented in Table ES-4.4-1, ES5.4-1 and ES-6.4-1 for soils, water, and structures, respectively. These tables are summary tables and do not present the rationale behind the selection of these alternatives. This rationale can be found in summarized form in Sections 4.0, 5.0 and 6.0 of this Executive Summary, and in thorough detail within Volumes II through VI of the DAA report. A graphic representation of the selected alternatives for soils is presented in Figure ES4.4-1. The water selected alternatives are presented in Figure ES5.4-1. It should be noted that the graphical representations are not to scale nor do they represent the actual areas to be remediated, but are provided to give a general overview of the preferred alternatives.